NOVEMBER 1949

Journal

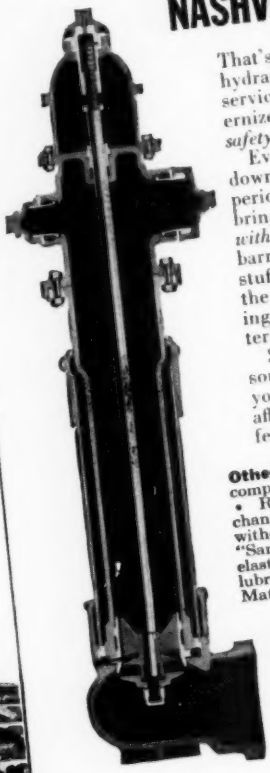
VOL. 41 • NO. 11

AMERICAN WATER WORKS ASSOCIATION

Piscatorial Eviction at West Orange, N. J.

Orange Reservoir Gets Its Triennial Seining

NASHVILLE, TENNESSEE



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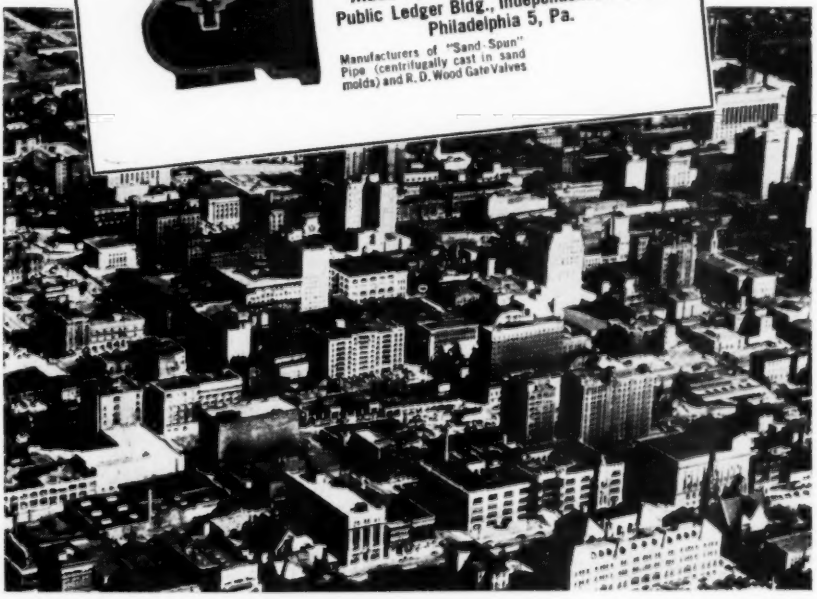

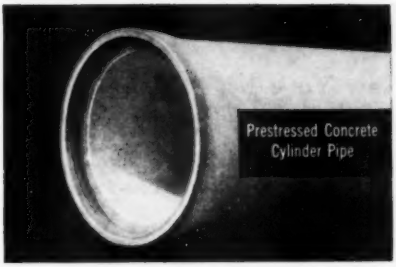

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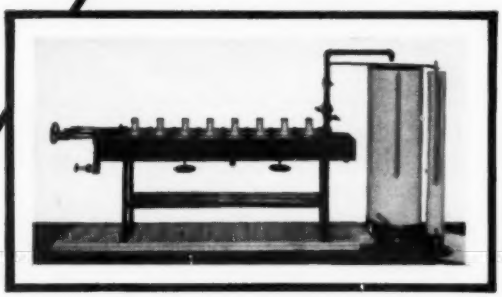

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Badger Meter Mfg. Co. 67
Barrett Div., The — —
Belco Industrial Equipment Div., Inc. — —
Bethlehem Steel Co. 65
Buffalo Meter Co. 33
Builders-Providence, Inc. 15, 61
Calgon, Inc. — —
Carson-Cadillac Co. 10
Cast Iron Pipe Research Assn., The 52–53
Central Foundry Co., The 20
Centriline Corp. 17
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Fairbanks, Morse & Co. — —
Flexible Sewer-Rod Equipment Co. vii
Ford Meter Box Co., The 45
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Graver Water Conditioning Co. — —
Hamilton-Thomas Corp. 13
Harco Corp., Rusta Restor Div. — —
Hayman, Michael, & Co., Inc. — —
Hays Mfg. Co. 77
Hellige, Inc. 22, 50
Hersey Mfg. Co. 49
Hungerford & Terry, Inc 56
Hydraulic Development Corp. 37
Industrial Chemical Sales Division, West Virginia Pulp & Paper Co. x
Inertol Co., Inc. — —
Infilco, Inc. 71
Iowa Valve Co. — —
Johns-Manville Corp. — —
James Jones Co. 69
Keasbey & Mattison Co. 35
Kennedy Valve Mfg. Co., The 47
Klett Mfg. Co. 54
Koppers Co., Inc. — —
Kupferle, John C., Foundry Co. 58
LaMotte Chemical Products Co. — —
Layne & Bowler, Inc. 43
Leadite Co., The Cover 4
Lock Joint Pipe Co. i
Ludlow Valve Mfg. Co. — —
M & H Valve & Fittings Co. 73
Mueller Co. — —
National Cast Iron Pipe — —
National Water Main Cleaning Co. 7
Neptune Meter Co. iii
Northern Gravel Co. 72
Northrop & Co., Inc. 66
Omega Machine Co. (Div., Builders Iron Fdry.) 5
Peerless Pump Div. 39
Permutit Co. 21
Phelps Dodge Refining Corp. — —
Philadelphia Gear Works, Inc. 18
Photovolt Corp. — —
Pittsburgh-Des Moines Steel Co. — —
Pittsburgh Equitable Meter Div. (Rockwell Mfg. Co.) 80
Pollard, Jos. G., Co., Inc. 72
Portland Cement Assn. — —
Proportioneers, Inc. 41
Reilly Tar & Chemical Co. Cover 3
Rensselaer Valve Co. 9
Roberts Filter Mfg. Co. 51
Ross Valve Mfg. Co. 59
Simplex Valve & Meter Co. 63
Smith, A. P., Mfg. Co., The 55
Solvay Sales Div., Allied Chemical & Dye Corp. 46
Sparling, R. W. 22
Standard Pipeprotection, Inc. 57
Stuart Corp. 40
U. S. Pipe & Foundry Co. v
Virginia Smelting Co. 38
Walker Process Equipment, Inc. — —
Wallace & Tiernan Co., Inc. xii, 79
Warren Foundry & Pipe Corp. 23
Well Machinery & Supply Co. 19
Welsbach Corp., Ozone Processes Div. — —
Wood, R. D., Co. Cover 2
Worthington-Gamon Meter Co. 29

Directory of Professional Services—pp. 24-27

Albright & Friel, Inc.
Alvord, Burdick & Howson
Bays, Carl A. & Assoc.
Behrman, A. S.
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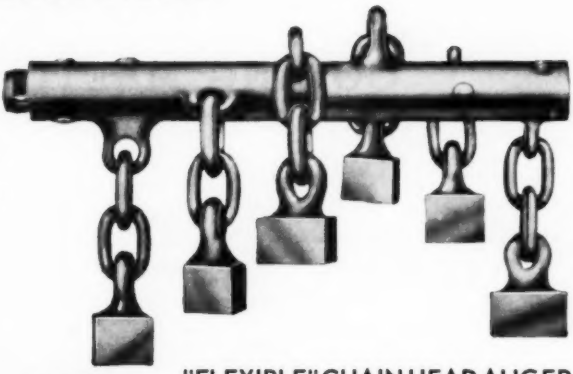

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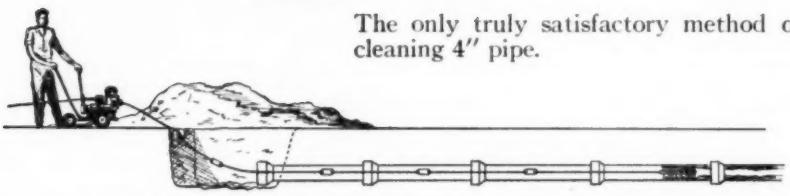

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17–19—New Jersey Section at Madison Hotel, Atlantic City, N.J. Secretary: C. B. Tygert, Wallace & Tiernan Co., Inc., Box 178, Newark 1, N.J.

December 1–3—Cuban Section.

5–7—Southeastern Section at Gordon Hotel, Albany, Ga. Secretary: T. A. Kolb, San. Engr., State Board of Health, Wade Hampton Bldg., Columbia, S.C.

January 13, 1950—New York Section Midwinter Luncheon at Hotel Statler, New York, N.Y. Secretary: R. K. Blanchard, Room 1922, 50 W. 50th St., New York 20, N.Y.

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Contents

Rethinking Water Rate Structures—*Panel Discussion*
LOUIS E. AYRES, E. F. DANDRIDGE, A. P. LEARNED, REEVES NEWSOM, RICHARD H. ELLIS, MELVIN P. HATCHER, NATHAN B. JACOBS, CHARLES H. CAPEN & HAL F. SMITH 953

Main Extension Problems in Indiana.....FRED R. WITHERSPOON 978

Determination of Total Hardness in Water by Direct Colorimetric Titration, *abstract*.....J. D. BETZ & C. A. NOLL 982

Diversion of Water Department Reserve Funds—*Panel Discussion*
WENDELL R. LADUE, E. ARTHUR BELL, JOHN C. DETWEILER, C. M. MCCORD, ALBERT R. DAVIS, D. D. GROSS & W. C. MORSE 983

Municipal Water Use in the United States.....W. B. LANGBEIN 997

Current Developments in Ground Water Law—*Panel Discussion*
C. H. BECHERT, GEORGE S. KNAPP, HOWARD T. CRITCHLOW, J. C. THOMPSON, ARTHUR H. JOHNSON & RALPH J. BERNHAGEN 1002

Deep Well Pump Testing.....FRANK C. MIRAMONTES 1013

Effectiveness of Silver Ions Against Cysts of *Endamoeba histolytica*
WALTER L. NEWTON & MYRNA F. JONES 1027

Experimental Studies of Odor Control at Whiting, Indiana
LEO BESOZZI & J. C. VAUGHN 1035

Revision of Recommended Practice for Tank Inspection, Repair and Repainting —7H.2–T 1046

Remodeled Cornell University Filter Plant.....F. R. GEORGIA 1047

Departments

Cover Story	*text p.* 977	Membership Changes	28
Officers & Directors	ii	Correspondence	40
Division & Section Officers	iv	Condensation	44
List of Advertisers	vi	Section Meeting Reports	60
Coming Meetings	viii	Service Lines	70
Percolation & Runoff	1	Index of Advertisers' Products	74

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Harry E. Jordan, Secretary—500 Fifth Avenue, New York 18, N.Y.

ERIC F. JOHNSON, *Editor* — LAWRENCE FARBER, *Associate Editor*
DANIEL N. FISCHEL, *Managing Editor* — ELIZABETH M. BRADY, *Associate Editor*

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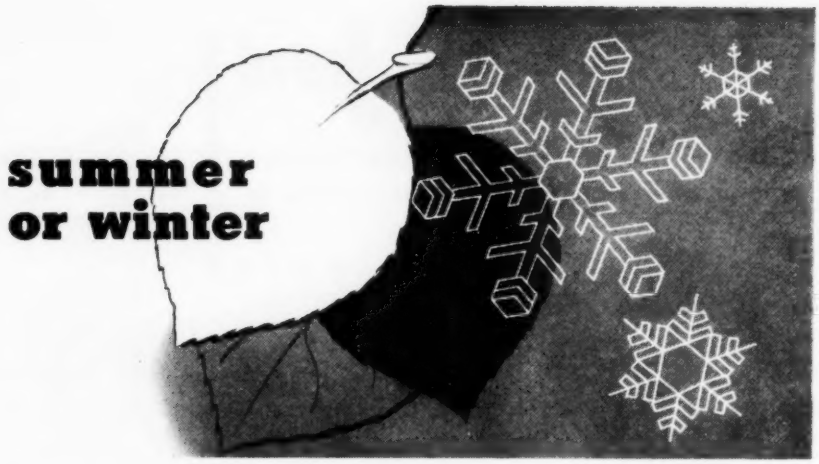

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Journal

AMERICAN WATER WORKS ASSOCIATION

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Rethinking Water Rate Structures

Panel Discussion

A panel discussion presented on June 2, 1949, at the Annual Conference, Chicago.

Louis E. Ayres

Civ. Engr., Ayres, Lewis, Norris & May, Ann Arbor, Mich.; Chairman, A.W.W.A. Committee on Water Rates.

THIS period is one of intense interest in the subject of rates, both water and sewage. The A.W.W.A. has recently appointed a committee on water rates; and, under the sponsorship of the American Society of Civil Engineers, and the chairmanship of Samuel A. Greeley, there has been formed a "Joint Committee on Fundamental Considerations in Rates and Rate Structure for Water and Sewage Works," including representatives from the American Bar Assn., American Public Works Assn., Municipal Finance Officers Assn., Federation of Sewage Works Assns., National Assn. of Railroad and Utilities Commissioners and the A.W.W.A. D. L. Erickson, of Lincoln, Neb., is the contact man between the joint committee and the A.W.W.A. committee. It may be added that the joint committee proposes to deal with *fundamental considerations* in both water and sewage rates, and the A.W.W.A. committee is, at present, limiting its studies to specific theories and principles related to water rates.

One may not question the desirability of constructive thinking on the subject of water rates. A "review of the existing situation . . . suggests an amazing confusion about the basis for their determination and a wide diversity not only in existing rates, but in the schedules being currently proposed by leading water works engineers." It would appear that many existing rate schedules have been determined by individual judgment to meet "local choice," and "defended by reference to the records of rates elsewhere." It is too much to hope that any rate structure can be devised that will be generally acceptable or generally applicable, but it should be possible to develop some underlying theories that "will at least reduce the amount of judgment which must be used and increase the amount of application of scientific principles." Such

is the ambitious objective of the A.W.W.A. committee.

This panel discussion will deal with certain specific questions, basic to water rates, which are discussed in a report of a committee of the Michigan Section, A.W.W.A., previously published (1). Concisely stated, these questions are:

1. How much revenue should a water works receive?
2. In what proportions should this gross revenue be collected: (a) from property assessments and (b) through utility rates?
3. Should utility rates incorporate a "demand" or "ready-to-serve" charge; and, if so, upon what logical basis should the amount of such a charge be fixed?
4. If a "demand" charge is to be used, upon what basis should it be distributed to customers?
5. Finally, how many steps are desirable in the commodity rate; and what are the logical rules for fixing the step quantity limitations and the unit rate for each step?

Amount of Revenue Needed

In considering the question of the amount of revenue a water works should receive, a distinction may be made between privately and publicly owned water works. The proper gross income of a privately owned utility has been the subject of many decisions of courts and commissions. It has generally been defined as the amount that will pay all expense of operation and maintenance, taxes and depreciation, plus a fair return on a fair valuation of the used and useful property.

Many writers on rates have assumed that publicly and privately owned water works should use exactly the same basis; but commonly, with municipally owned plants, a "cost" basis prevails "on which the dollars collected are realistically justified by a budget of expenditures that can be made obvious to a city council or commission." Interest is paid on outstanding bonds only; taxes are rarely included; and in lieu of or supplementary to depreciation, one finds allowances for replacements and extensions. For any particular community, the final answer is likely to depend upon the viewpoint of its officials and to be a compromise between the private utility basis and the so-called cash basis. In a city borrowing money under a revenue bond act, the law may determine the rate base and, as in Michigan, require an income to provide for operation and maintenance, bond interest and retirement, and replacements and improvements, but no depreciation as such, no taxes and no interest on debt-free property.

Having determined the gross total of income needed, the second question is how it should be allocated to (a) property assessments, and (b) utility rates; or to (a) nonusers and (b) users, the terms recently adopted by the joint committee.

It is generally accepted that a water works has two principal functions: it performs a service and supplies a commodity. "General municipal service" has been described as covering "all those benefits which are chargeable to the taxpayers as a whole and includes the additional cost . . . for fire protection; the increased value of the property in the city due to the existence of a water works system; and the intangible value of the good health of the community, due to a pure water supply."

Fire Protection Charge

The one element in water works cost that may be evaluated with some degree of precision is fire protection. The

classical paper in water works literature on fire protection is that of Metcalf, Kuichling and Hawley (2) published in 1911. It is probable that the results of this paper have been applied many times on a population basis without following through with a careful application of its principles to local conditions. To do so is not an easy task. The Michigan Section committee report suggests the search for a relatively simpler rule, the application of which would yield an approximately equitable result. Perhaps the capital costs chargeable to fire protection might be based on the ratio of the maximum fire demand to the total combined demand, multiplied by the ratio of the increase in cost to the increase in capacity.

Theoretically, there should be a charge for fire protection, but, practically, there are difficulties involved in its application. It is related to the subject of taxes, and because of this complication, very few publicly owned water works can find any extra money from taxes to pay for fire protection. Privately owned plants receive hydrant rentals *and* pay taxes. Publicly owned plants, financed by revenue bonds, are sometimes required by law to forego the practice of supplying "free water" and must, therefore, make a hydrant rental charge. This division of the burden between users and nonusers is a subject to which the joint committee is directing its attention both in water and sewage rates, and its statement of the fundamental bases for determining such charges is being awaited with interest by the A.W.W.A. committee.

Ready-to-Serve Charge

Ever since water rates were devised, engineers have assumed—taking their cue from the electric industry—that some portion of the charge should be based on the assumption that the water plant first stood ready to serve its customers and for that "readiness" it should receive an income. Then the plant would start serving and charge so much a unit for the water delivered.

In the early days the New England Water Works Assn. treated this first charge as a "service" charge and not a "readiness-to-serve" charge. It was confined to [1] service pipe and meter costs; [2] reading, billing and collection expense; and [3] the cost of lost water. To that basis the Michigan Section committee has returned. But *Water Works Practice* (3) went far beyond the N.E.W.W.A. basis and recommended that "ready-to-serve" costs should include "interest, taxes, depreciation and a certain portion of operating expense" for the entire water works plant.

"Examining the literature on the subject of water rates over the past 30 years, one finds a wide range of assumptions" in the application of this theory (1). The minimum is limited to actual costs of services and meters, plus reading meters, billing, collecting and bookkeeping. *Water Works Practice* concludes that ready-to-serve costs should be less than one-half of the total. Others have limited the basis for the charge to fixed costs only. A recent extreme schedule allocates 95.8 per cent of total costs to users on a basis independent of the amount used.

The Michigan Section committee, after examining all of this evidence, concluded: "There is no place along the line at which one may stop logically. The charge cannot be applied except arbitrarily, or on the basis of judgment and precedent elsewhere." The committee therefore discarded the theory, except as a basis for fixing fire protection charges and perhaps in special sit-

uations when large users or areas are served through recording meters.

Although the first reason for abandoning the "ready-to-serve" charge was that there does not appear to be any logical basis for determining its proper amount, the second reason, of equal or more force, is the absence of an equitable basis for allocating the charge to the mass of individual users. The electric industry employs a demand meter for the larger user, and in a water works larger users may be served through recording meters. The theory could be applied to these customers if agreement could be reached on the *amount* of the charge to be made for "demand." The ordinary water meter, however, is an instrument to measure "use" and not "demand," and the relationship varies widely. To make the ordinary meter applicable requires an infinite number of meter sizes, each installed to meet the customer's needs exactly, taking into account both volume and service pressure. Water works are, therefore, confronted with the problem of distributing to the customer demand costs amounting to 50 per cent or more of the total system costs without an instrument designed to measure individual demands. Hence, the A.W.W.A. committee asks: "Upon what basis should demand charges be distributed? If on the basis of capacity ratios of meters, what capacity ratios should be used?"

The Michigan Section committee reviewed the capacity ratios in use in many schedules and found that the relative capacities of a 6-in. and a ⅝-in. meter frequently vary 100 per cent in practice, with a maximum range in excess of 300 per cent. "Obviously these variations materially affect the distribution of costs to the customers. . . . One may well be puzzled to decide what capacity ratio basis should be adopted; and it seems reasonable to conclude that the choice must be arbitrary."

Rate Steps

The A.W.W.A. standard form of rate schedule provided for three slides or steps, with "a fourth and lower rate for large manufacturers, if deemed desirable" (3). A review of existing schedules discloses from one to a dozen steps, and it is common to find five to seven. Upon what basis these steps are determined is undisclosed; but, more important, how the unit rate or charge for each step is determined defies analysis.

The nearest approach to a theory for the several steps is the suggestion that there be a step for each size of meter. But the only difference in unit cost for water delivered through a 1-in. and a 2-in. meter is the difference in investment and maintenance of service and meter. If the ready-to-serve charge were capable of equitable application, there would be much to be said in favor of a single step.

The objectives sought in an ideal water rate schedule are: [1] that a liberally adequate revenue be provided; [2] that the schedule be reasonably simple of application; and [3] that it distribute the burden with approximate equity between users and nonusers of the service.

A brief outline of the plan of the Michigan Section committee, as given in its report (1), is set forth below:

"The committee's proposed rate structure follows closely the form of the A.W.W.A. rate schedule, adopted May 24, 1923." After separating from the costs those chargeable to fire protection and general public service, the committee proposes to collect the balance through a schedule to users consisting of "a meter service charge plus

a commodity charge applied in three steps."

The meter service charge is to include:

1. All commercial expense and a suitable portion of administrative and overhead costs, the total of which is to be divided *equally* to all accounts.

2. All expense arising out of meters and services, with a share of administrative expense and overhead, the total of which may be distributed between accounts on the basis of the *meter* cost. . . .

3. There should also be added . . . for all minimum users, the cost, based on the domestic commodity rate, of the minimum desirable use from the standpoint of sanitary conditions or, say, 100 gpd. per meter.

The commodity unit rates may be determined as follows:

1. The *wholesale unit rate* is obtained by dividing the total of all production and transmission expense (capital costs and operation and maintenance), plus a portion of administrative expense and overhead, by the total annual pumpage.

2. The *intermediate unit rate* is obtained by adding the intermediate increment to the wholesale rate. The intermediate increment is obtained by dividing the total expense arising out of distribution mains larger than 6 in. by the water sold through all meters, except sales at the wholesale rate.

3. The *domestic unit rate* is obtained by adding the domestic increment to the intermediate rate. The domestic increment is obtained by dividing the total expense arising out of distribution mains 6 in. and smaller, plus the cost of all lost water, by the water sold through all meters ¾ in. and smaller.

The committee suggestions on the determination of step quantity limitations are:

Step quantity limitations must be adopted which, when applied to the unit rates, will produce the necessary revenue; and the quantity limitations and unit rates must be checked as a whole against the system's customers.

The committee suggests that, as an initial determination of step quantities, the domestic rate apply up to a quantity equal to twice the average consumption through all domestic meters, ¾ in. and ⅝ in.; that the intermediate rate apply up to a quantity equal to twice the average consumption through all intermediate meters; and that all quantities over the intermediate limit fall under the wholesale rate.

The A.W.W.A. committee will attempt in the months ahead to follow through on the several subjects previously outlined, in order to reach common ground as far as possible. When agreement is not possible, the range of opinion will be stated and discussed. From that point, the committee will depart into a consideration of side and related issues, some of which have already been suggested by committee members.

The committee invites the members of this Association to send it their comments on this panel discussion and on the Michigan Section committee report.

Through the cooperation of D. L. Erickson, the committee also hopes to be aided by and to aid the joint committee, which represents a cross section of all those interested in the subject of rates.

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Amount of Revenue Needed

E. F. Dandridge

Executive Staff Assistant, Dept. of Water & Power, Los Angeles.

The discussion of how much revenue a water works should receive must be limited by excluding those utilities depending substantially upon the proceeds of taxation and contributions, in addition to water rates, as regular sources of income. For such utilities, the determination of rates must be a custom-built job. This paper assumes, therefore, that, within reason, the total financial requirement of the water works is to be met from revenue. Consequently, the amount of revenue a water works should receive is the same as its financial requirement, and the problem is reduced to determining what the financial requirement is. It is best to analyze the items which constitute the financial requirement, classifying them into groups and arriving at a total requirement for each group. Some items will, of course, not be applicable to both privately and municipally owned water works. A list of such groups is given below:

Requirement	Private Utility	Municipal Utility
Operating expenses	Yes	Yes
Maintenance expenses	Yes	Yes
Taxes	Yes	Yes
Depreciation	Yes	No
Renewals and replacements	No	Yes
Rate of return	Yes	No
Debt service	No	Yes
Additions and betterments	No	Yes
Contributions to city	No	Yes

Having determined the types of expense to be met from revenues, it is necessary to ascertain what the proper amount of each class of expense will be. Usually standards must be established which will represent the long-term policy to be followed and which will, to a greater or lesser extent, influence the amount properly chargeable to each class.

Operating expenses. Sufficient operating expenses are required to provide economic and efficient operation of the water works, and will be the same regardless of type of ownership.

Maintenance expenses. The requirement for maintenance should be the amount necessary to maintain the plant in operating condition consistent with the lives assumed for depreciation purposes. This amount should not differ because of type of ownership. The fact that, under municipal ownership, depreciation is not considered a factor in rate-making does not diminish the need for a sound depreciation policy.

Taxes. The requirement for taxes should be the amount which the utility must pay as a proper charge against income. The private company will be required to pay taxes which the municipally owned company will not, but, to the extent that taxes are paid, this requirement should be the same regardless of ownership.

Depreciation. The privately owned company will be entitled to include depreciation as a financial requirement. It is most important that a realistic life expectancy be used in establishing depreciation rates. For the purpose of defining more clearly the charges which can be included under maintenance and arriving at a realistic depreciation policy, the following definition of depreciation, suggested by the American Institute of Accountants, is given:

Depreciation is a word . . . used in accounting to describe a charge that is made currently against operations on account of the inevitable and indeterminate partial exhaustion, not preventable by expenditures chargeable to maintenance, of the useful life of instruments of production or distribution, or of a group or assemblage of such instruments whose useful life is limited but is expected to extend over a number, usually not less than three, of accounting periods.

Renewals and replacements. The financial requirement for renewals and replacements applies only to the municipally owned utility. This requirement will normally be found to be less each year than the requirement for depreciation would be. Allowance for replacements, however, is the nearest equivalent in municipal operation to depreciation in private operation. The amount should be that which is necessary to maintain the plant in efficient operating condition.

Rate of return. Most people agree that the proper method for determining the amount of return which a privately owned utility should receive is to multiply the value of the property by a percentage representing the rate of return. It has been pointed out by various authorities on the subject, however, that few can agree upon either the value or the rate. But regardless of the question of values or rates of return, the common-sense approach to the problem is that the earnings of any privately owned utility must be sufficient to maintain its financial integrity and ability to attract new capital in fair competition on the money market. This amount may vary from time to time and with respect to different companies.

Debt service requirements. Most municipally owned utilities will be required to pay interest upon outstanding debt and at the same time to amortize the principal. The annual debt service requirements will be influenced very largely by the policy which is utilized in connection with the financing of additions and betterments, but once that policy has been established, the debt service requirement will be determined by the terms of the outstanding debt.

Additions and betterments. The annual requirement upon revenues for additions and betterments will be determined by a comprehensive, long-term study of what improvements will be necessary from year to year and how much of the cost of such work will be provided out of proceeds from the sale of bonds or other securities. An important point in the determination of borrowing policy will be the extent to which it is desirable to become debt-free. Any program providing for additions and betterments to be made on a pay-as-you-go basis out of revenues ignores the important fact that the investment in a water plant is usually good for many years to come. On the other hand, if too much emphasis is placed upon the longevity of water works facilities, and long-term bonds are utilized wholly to finance such work, the result is to maintain debt service requirements at a higher level than is desirable.

Most municipally owned utilities go through stages from almost utter dependence upon taxation for their existence to a point when revenues will provide the total requirements of the plant, assuming that rates have been properly fixed. At the appropriate time in this transition, to provide a leveling off of rates, the most liberal policy is to have 50 per cent of the cost of additions and betterments come directly from revenues during a given pe-

riod, with the balance being financed by proceeds from the sale of bonds.

Contributions to city. As more and more municipally owned water works have become self-sustaining, two tendencies have prevailed. One has been the failure to keep the funds derived from the sale of water separate from funds maintained for other city purposes, on the theory that the water system is just another city department and not a proprietary function. The other tendency has been to maintain the integrity of water revenue funds, subject to constant pressure for the transfer of the largest amounts possible to the general fund of the city.

There is much to be said on both sides of the question of diversion. The theory has been advanced that rates for municipal water service should be fixed to include a rate of return and an amount equivalent to the taxes which would be paid if the water works were privately operated, the total to be paid to the general fund of the city. It has also been argued that the people wish to provide themselves with a water system, whatever the cost may be, and that it should be placed on a self-supporting basis as rapidly as possible, with its only obligation being to continue to serve adequately the needs of the community.

The decision on this matter might properly rest with the people, but it appears that neither those in responsible charge of the water works nor the governing body of the city is willing to have the question resolved by the people following a factual presentation of the problem.

There does appear to be fair support, however, for the settlement of this question by the transfer of funds approximating the amount of taxes which the municipality would be paid if the utility were privately operated. It is therefore recommended that the contribution-to-city requirement be determined upon this basis, provided that the water revenue fund receives cash payment for all services furnished other city departments, including an annual charge for public fire protection through fire hydrants, the amount of which approximates the cost of the degree of protection provided.

A. P. Learned

Prin. Engr., Black & Veatch, Kansas City, Mo.

A water utility, whether privately or publicly owned, should receive sufficient revenue to cover the cost of service, which is normally considered as including the following general subdivisions: [1] operating expense, [2] maintenance, [3] depreciation, [4] taxes and [5] return on investment or cost of capital.

These elements of cost are used in testing the reasonableness of rates for a private utility and also have a place in testing the adequacy of municipally owned water utility rates. The terminology used, however, may vary in accordance with legal requirements or with the financial practices of the individual municipal utility. Usually, too, amortization of debt is a factor in municipal utility rates but not in those of a private utility. Moreover, a municipal system may be exempt from taxation. These points of difference will be discussed in conjunction with the appropriate element of cost of service.

The amount set aside for operating expense and maintenance should be adequate to keep the plant running efficiently and in proper condition, as well as to retain the services of competent

personnel. Maintenance should include repairs and replacements that are not properly chargeable to the depreciation reserve, or, conversely, maintenance should not include any item normally treated as an addition to or retirement of plant.

Depreciation should be an annual charge sufficient to provide funds equal to the original cost or that cost less salvage at the time of retirement of units of property. The depreciation reserve is normally invested in additional property, and actually at the time of retirement it is not in the form of cash but in kind, so that the integrity of the investment is preserved.

The annual depreciation charge may vary in different plants even when based on the same premise, depending on the ratio of short- and long-lived properties in the respective utilities. This annual charge, when made, ordinarily ranges from slightly less than 1 per cent up to 2 per cent.

Some states provide for the payment of a part or all of the cost of a distribution main by a front-foot assessment, or, if the main is larger than immediately required, by an improvement district assessment. In such instances, some municipal water departments do not provide a depreciation charge for this type of investment. It is good foresight, however, to maintain a depreciation reserve even under such circumstances because all of the extensions will not need to be replaced at one time and the cost will therefore not be readily reassessable.

It is highly questionable whether the full depreciation charge should be included in addition to an amortization charge for debt retirement. It is, in fact, a double charge; however, eliminating the depreciation charge entirely will mean a repetition of the financing of the municipal utility plant at the time of retirement. Such a replacement operation is normally chargeable against the depreciation reserve.

In the last twenty years a number of states have provided for financing municipal utilities by means of revenue bonds. The laws under which such bonds have been issued usually provide special protection for the payment of interest on, and amortization of, bonded debt. In some states provision is made for other charges corresponding to depreciation even if not so designated. Such laws usually protect only the integrity of the specific investment covered by the revenue bonds and not the replacement or depreciation reserve on the remainder of the property.

A number of municipal utilities try to operate on a cash basis—that is, they do not use bond financing for normal and current extensions. Under such circumstances, it is usually imperative that there be more funds available for reinvestment per year than will be provided by a proper annual depreciation charge. It has been suggested that such an additional charge might be made in lieu of or supplementary to a depreciation charge. The propriety and value of such a provision is discussed later, under return on investment.

Taxes

Some municipal utilities pay taxes, while others do not. If the municipal corporation pays the municipal utility for all services rendered, it seems logical for the utility to pay taxes. This procedure will result in the equitable sharing of the burden if the rates are proper. The practice may be confined to municipal taxes only. Such a procedure is applied at times to customers outside a city, but not to those within

the city; that is, taxes are included in the cost to customers outside the city.

It has been suggested that a tax charge might more properly be applied to a municipally owned electric utility; however, there seems little reason for this differentiation. Investment in municipal electric utilities until recent years varied from $300 to $500 per customer, and many municipal water systems cost from $300 to $400 per customer. The average annual revenue per customer is not so high in the water works as in the electric utility, but neither are operating costs normally so high a percentage of the total revenue in a water utility.

Some municipalities in their search for more revenue have imposed a charge on the municipal utilities based on a percentage of the gross receipts. Some cities regard it as a supervisory charge and others merely as a means of securing more money for general expenses without using the taxing formula.

Irrespective of the name, it appears that municipal water utilities will more and more be subject to what is very properly styled "taxation."

Return on Investment

Return on investment or bond interest or the cost of hiring money is a charge which a municipal utility pays on all of its debt structure and which may not be imperative if the utility is entirely debt-free. The private utility always has this cost. It seems entirely logical, in a municipal utility, that the cost of service include an item for such a charge even though the utility is debt-free, to furnish the funds to supplement the depreciation reserve in providing for normal and current expansion. Such revenue, if providentially handled, is completely effective and avoids any charge for interest or the hiring of money. A study of a number of growing municipal utilities shows annual additions of 1–4 per cent of the total plant account. Provision for return even on debt-free property will thus supply needed funds.

Although a particular utility may not use the terminology for charges outlined above, eventually the cost of service must either directly or indirectly be met and will reflect in some form the basic elements previously described.

Depreciation and the Rate Structure

Reeves Newsom

Village Mgr., Scarsdale, N.Y.

Providing for the depreciation of the facilities of a municipally owned water works plant is generally done only by indirection. Proceeding upon the theory that improvements and extensions, and replacements as well, will be paid for by the issuance of bonds, the successive water works administrations are usually content to pay off the bonds maturing each year, together with the interest due. They feel that, by thus reducing the indebtedness of the system and preparing for future borrowings within reasonable debt limits, the necessary replacement of all elements of the works as they are retired is being properly provided for.

This method has worked satisfactorily in most communities, but the interest cost is little realized by the water consumer. During 1921–32 a certain water department borrowed nine times in a total amount of $1,075,000, at rates varying from 4¼ to 5½ per cent, with maturities varying from 25 to 40 years. The total interest to be paid to maturity on those bonds

is roundly $910,000, or 84.6 per cent of the principal. In other words, every extension and replacement financed during that period cost 1⅛ times as much as it was supposed to. At today's interest rates and with shorter maturities, the interest cost would, of course, be materially less, but if the borrowing method is continued it cannot be abandoned when interest rates get high again unless accruing depreciation and the cost of future extensions are being provided for in the meantime by reserves or surplus.

The shift from financing by borrowing to a pay-as-you-go policy, which of necessity includes accumulations of reserves against large expenditures in certain future years, cannot ordinarily be accomplished without a material increase in rates. There usually will be a period in which not only is old debt being retired but reserves are being accumulated in order to avoid future borrowing. It is necessary to go through such an era only once, however, and as borrowing ceases the old debt service tapers off and soon becomes less burdensome.

The inclusion in the rate structure of a proper annual provision for depreciation, thus postponing the time of and the need for future borrowing, would appear to be the least that should be done. The cost of replacing facilities that wear out or become obsolete in the service of the water customer is certainly an element of operating expense and, as such, should be provided for in the rates paid by the one receiving the service.

Depreciation Methods

It should be borne in mind that most water works systems are relatively new as compared with the life of the principal element of the works, cast-iron pipe. Although straight-line depreciation is simple to calculate and is, for purposes of accounting, very often recommended by public utility commissions, it is quite feasible and adequate for a municipal department to use some form of compound-interest method to compute its accruals.

The studies and report of the Association Committee on Survival and Retirement of Water Works Facilities furnish ample evidence that, based on actual occurrences in numerous representative cities in North America, the need for a sizable depreciation reserve develops slowly. The committee report also indicated very much longer service lives for cast-iron mains 6 in. and larger, as well as for certain other plant elements, than was commonly realized prior to the factual study on which the report was based.

The use of a compound-interest method at, say, a 3–4 per cent rate, approximates the way in which actual depreciation and the need for replacements accrue in a water plant. It takes into account the fact that retirements of the principal elements of a water works plant are not brought about primarily by physical deterioration. It allows for the fact that during the early years of the service life of long-lived facilities, the range of conditions under which such facilities have been designed to operate can be seen with a greater degree of accuracy than in later years; that retirement because of inadequacy or obsolescence will be the result of factors which ordinarily develop at a much faster rate after that early period; and that, in general, the older a facility becomes the less accurately the designer anticipated, originally, the changes in operating conditions.

If, however, the straight-line method of depreciation accounting is preferred, it can still be used if full advantage is

taken of the long service lives indicated by the above-mentioned report. In fact, if a water system of some substantial age starts now to provide for accruing depreciation, there is an advantage in using some accelerated form of computation, such as straight-line accounting, in order to accumulate a reserve more rapidly than depreciation is accruing. When an adequate cushion has accumulated, the annual depreciation rates to be applied to the replacement costs of the various facilities can be reduced, either arbitrarily, based on judgment, or after studies of the particular needs of any individual system as evidenced by its own retirement experience and the indicated mortality survival curves resulting therefrom.

The author's observation of the relative adequacy of depreciation reserves set up by half a hundred private water companies, with which he has been associated, indicates that a reserve of around 15 per cent of the replacement value of the plant will ordinarily meet the need for retirements; and adjustments in annual rates at about five-year intervals to hold the reserve at or near that amount is a practical way to proceed. To be sure, under special conditions, such as the necessity for abandoning the source of supply, the level to which the reserve should accumulate may be much higher. Perhaps, at today's low interest rates and high cost of replacements, a reserve of 20 per cent of original cost might be indicated.

If a water works plans to continue to finance its improvements by the issuance of bonds, the depreciation reserve after caring for current replacements should be invested in new plant, thus postponing borrowing to whatever extent such reserve will cover extension requirements. If, on the other hand, a water system adopts the pay-as-you-go method of financing new works, its depreciation reserve should be held in cash or invested in legal and negotiable securities readily convertable when required, as should also any capital reserves for improvements.

A proper rate structure should produce revenue enough to cover a provision for annually accruing depreciation.

Fire Protection Charge

Richard H. Ellis

Hydraulic Engr., Eng. Div., Associated Factory Mutual Fire Insurance Cos., Boston, Mass.

In any discussion of rates, water systems, whether publicly or privately owned, should be considered self-supporting business enterprises. As such, the total revenue received should be adequate to meet all expenses, to provide a sufficient surplus to offset depreciation and—for privately owned utilities—to provide a fair profit. These requirements, of course, are fundamental to any business.

Everyone today is particularly conscious of the materially increased operating expenses which result from current labor and material costs. The natural reluctance of public officials to take any action which may arouse public opposition frequently results in a lag between increased operating costs and necessary rate increases. Lack of funds to carry out necessary maintenance and provide for additional plant capacity, needed improvements and extensions inevitably results. Many water works now have no alternative but to seek additional revenue. The adjustment of rate structures is there-

fore a pertinent subject at the present time.

The establishment of rates should be based on cost figures. The factors to be considered are: [1] capital investment, [2] operating costs, [3] maintenance costs, [4] depreciation and [5] amortization of bonded indebtedness. The proper allocation of these costs to the water sold and service rendered should furnish an equitable basis for rate making. As water systems principally furnish [1] water for domestic and industrial use and [2] fire protection, the expenses involved therein should be considered in the revision or establishment of rate schedules.

Although no rate schedule will be perfect in all details, it is evident that the practice of raising all revenue through the sale of water alone—that is, through a charge for water—often results in injustice. A lumber business, which may use a negligible amount of water and accordingly receives a minimum bill, pays practically nothing for fire protection although its demand may be large. On the other hand, a dye house or other large customer may assume a greater-than-justified share of the cost of providing fire protection while possibly creating less of a demand for this service.

Because of the different types of water systems, and the varying proportions between the ordinary domestic and industrial loads and the peak demand created by fire in communities of different sizes, no general formulas have been found which are universally applicable. Metcalf, Kuichling and Hawley in 1911 outlined a procedure that forms a practical standard in calculations of this nature. The study of individual systems requires a careful evaluation of the costs of the various factors involved in producing, treating, storing and distributing water and division of the cost of each of these items in proportion to their use in supplying fire and ordinary demands. The 1911 study indicates, in general, that the cost of the portion of the water plant involved in fire protection service would constitute possibly 60–80 per cent of the entire cost of the physical property in communities of 5,000 population or less; 20–30 per cent in cities of 100,000 population; and 10–20 per cent in larger cities. The cost of the various elements has, of course, risen greatly since 1911, but the proportions are probably not far different. It is presumed that current studies on the same basis would in general give about the same results.

Present Practice

Despite the publicity that has been given this subject, surprisingly little has been accomplished. An analysis of the data collected by the A.W.W.A. for 1945 indicates that only 197 water works out of a total of 462 replying to the Association's questionnaire actually collected anything from their respective communities for fire protection service. A somewhat similar questionnaire sent out by the author in 1949, to which about 1,100 replies have been received, shows an even smaller proportion of water works receiving revenue from this source. The latter canvass involved communities of less than 10,000 population, which were not included in the A.W.W.A. returns.

Many of the water works reporting revenue from fire protection service are actually collecting only "token" charges. When rates are collected for such service, the amount received varies from 0.2 to 52.4 per cent of the total revenue from all sources. Except for one city of 30,000 population and three

with a population of approximately 200,000, few receive anything near the proportion indicated as being justified by the Metcalf, Kuichling and Hawley formula. In one state, where municipal works are under public utility regulations, the average receipts from general fire service are 22.1 per cent of the total receipts. The average in three states is between 10 and 20 per cent; in fourteen states, between 5 and 10 per cent; and in sixteen states, between 0+ and 5 per cent.

Statistics on the collection of fire service rates are still further confused by the fact that some water departments pay taxes on the assessed value of their holdings while most others are tax exempt. Occasionally tax exemption may be considered as offsetting the charge for fire protection and, in such instances, it should be understood that reimbursement, in some degree, is thus being received for that portion of the water works expense incurred in providing general fire protection service.

One probable reason for the hesitation in collecting fire service rates from municipalities is the resulting effect on tax rates. Right or wrong, officials are reluctant to add anything to a rising tax rate and, during periods of business depression, strive to reduce tax rates as much as possible. The water works manager or superintendent, although recognizing the injustice of doing so, is often obliged to continue to collect all revenue from the sale of water alone.

Numerous public works departments today render bills for both water and sewer service. It seems feasible to divide the rates so that the bills rendered to property owners might carry charges both for water consumed and for fire protection service, based upon the assessed value of the property served. This practice would produce a more equitable water rate, give relief to the large consumer of water and levy the fire service charge in proportion to the value of the property protected.

In the establishment or revision of a rate structure, serious attempts should be made to segregate expenses so that water works products or services can be properly evaluated and their costs established on a firm foundation. It is the author's opinion that a strong effort should be made to collect for fire protection in proportion to the value of the property protected, preferably as an element of general taxation.

Much work still remains to be done on this phase of the rate-making study. Possibly some approximations can be made which will facilitate the application of the principles laid down in the 1911 study. Comments or suggestions from the members of the Association will be greatly appreciated.

Demand and Service Charges

Melvin P. Hatcher

Director, Water Dept., Kansas City, Mo.

In previous papers (1, 2), the author has stated his conviction that the readiness-to-serve charge has no place in water rates for the great majority of customers. This thesis can briefly be set forth thus:

1. The equation for water service cost for the residential and small commercial class of customers (who, in Kansas City, account for 95 per cent of the total) is not a constant plus a unit price per unit of water used.

2. Rather, the equation is more nearly a constant (meter maintenance and fixed charges and collection costs)

plus one unit price per unit of water used for household purposes (somewhere near 4,500 gal. per month in Kansas City) plus a higher unit price per unit of water used beyond this quantity.

3. This second, higher unit price results from the fact that residential consumption beyond the household purpose range is devoted primarily to lawn sprinkling and, to a lesser degree, to air conditioning. These two classes of service have load factors (ratios of average hour or day to maximum hour or day, respectively) that cause their cost to bear more fixed charges on plant and property than is attributable to the same quantity of water devoted to household uses.

4. Users of any utility service dislike a readiness-to-serve charge.

5. In Kansas City, between 75 and 80 per cent of the revenue from the residential–small commercial group comes from water sold above the household usage range.* It seems illogical, therefore, to strive for extreme precision in the placement of charges for service at the lower end of the consumption range.

6. A satisfactory compromise can be achieved by the use of a minimum charge, and water sold under that minimum charge need not have a unit cost much, if anything, in excess of the unit cost in the first block in the rate; that is to say, the minimum charge need not be boosted to include charges that might be otherwise dealt with as readiness-to-serve charges.

* It appears possible that 4,500 gal. per month may be lower than the average household usage. These percentages would be decreased by any increase in this figure, but it does not appear that the amount allowed is low enough to change the conclusion stated here.

Revenue and Cost Comparison

As a basis for this point of view, the author has made a determination of the cost of service within the range of consumption by the residential–small commercial class of customers. With some reservations, the figures given below are accurate enough for the purpose. The resulting cost curve has been compared with the cost of service under Kansas City's present rate † (Fig. 1). The revenue which would be collected

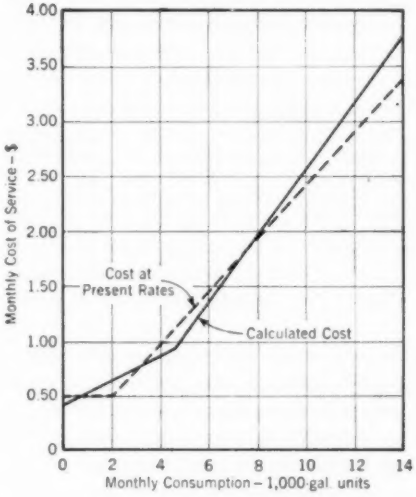

FIG. 1. Cost of Service

from significant groups of customers under the calculated cost curve has been compared to the revenue that is actually being collected.

The calculated cost-of-service curve was based on a 55,000-gal. annual consumption for household usage only and an 85,000-gal. annual consumption including the same household usage plus 30,000 gal. per year for lawn sprin-

† For the first 2,000 cu.ft. per month (which covers the range of consumption dealt with in this paper), 17¢ per 100 cu.ft.; minimum, 50¢ per month.

kling. A summary of these costs is shown in Table 1. The consumer cost in this summary was made to include meter-reading, billing, collecting and meter maintenance costs. The commodity cost included all other expenses, and the capacity cost included fixed charges on property.

The actual cost-of-service curve in Fig. 1 was developed from the figures in the summary above. The consumer cost is the constant or readiness-to-serve portion of the cost. The unit cost up to 4,500 gal. per month (55,000 gal. per year) in the household usage range is taken as the sum of the commodity and capacity costs divided by the quantity of water involved; this unit cost is 10.7¢ per 1,000 gal. Then the unit cost above 4,500 gal. per month is 30.8¢ per 1,000 gal.; this is reflected in the $9.25 difference in the totals for commodity and capacity costs for the additional 30,000 gal. of water per year.

TABLE 1

Annual Cost of Service

Cost Classification	55,000-gal. Use	85,000-gal. Use
Consumer	$ 5.22	$ 5.22
Commodity	3.81	5.93
Capacity	2.07	9.20
Total	$11.10	$20.35

The capacity costs were determined on the basis of studies of peak hourly and peak daily system demands and participation in these demands by all classes of service. The load factor data making up the basis for this participation was supported by considerable information arrived at from load studies, which are being continued. Later refinement of these studies may prove the need for some revisions of the cost data assembled for this paper, but it is believed that the determinations which have been made are accurate enough to justify the conclusions drawn from them.

The average residential–small commercial customer uses about 85,000 gal. of water in a year, for which he pays $19.00. The revenue for 1,000 average customers, by ranges of consumption, at the lower end of the consumption range, under the actual cost determination and under the rate as presently applied, would be:

Monthly Use *cu.ft.*	Actual Cost	Present Rate Cost
Up to 300	$ 1,322	$ 1,092
300–600	3,362	3,330
Over 600	14,316	14,578
Total	$19,000	$19,000

Kansas City's rate has a first step of 2,000 cu.ft. (15,000 gal.) at 17¢ per 100 cu.ft. or 22.7¢ per 1,000 gal. The minimum rate of 50¢ per month buys 300 cu.ft. The first group above therefore includes those using the amount supplied for the minimum charge. The cost of service exceeds the actual revenue by 21 per cent, but this excess amounts to only 1.2 per cent of the total revenue. The next group includes those using in excess of the amount supplied for the minimum charge and up to the amount used for household purposes. There is some shifting of the cost burden within this group but the total revenue figures are in excellent agreement. The calculated cost of service and the actual revenue are also in satisfactory agreement over the remainder of the consumption range.

Lawn Sprinkling Load Factor

This paper makes use of a premise that, to the author's knowledge, has not been dealt with in any water rate literature; namely, that the cost of providing water for lawn sprinkling is higher than the cost for household purposes. Whether this statement is true in all or most parts of the country will depend on the relative load factors for these two classes of service. It seems likely that the lawn-sprinkling use is of considerable consequence and that its load factor is not as good as that of household usage throughout most of the country. This observation is supported, for instance, by a statement in the 1948 annual report of the Minneapolis, Minn., Water Dept. that the rate of delivery to distribution dropped 50 per cent on the occasion of a rain at one time in the year. Such a condition is difficult to reconcile with the preferential rate of 6¢ per 100 cu.ft. for lawn sprinkling and air conditioning at Duluth, Minn.

The conclusions previously given do not necessarily rest on this premise, but they are influenced by it to some extent. It should be pointed out, too, that any attempt to give effect to this premise in the unit price at the upper range of water rates should recognize the incremental aspect of the cost of water for lawn sprinkling. If water for lawn sprinkling is charged with only the *incremental* cost of plant and mains, its unit price may not be much, if at all, above household usages. These points deserve more study.

References

1. Hatcher, Melvin P. Something New in Water Rates. Wtr. & Sew. Wks., **94**: 157 (1947).
2. ———. New Plan for Water Rates (*unpublished*).

Nathan B. Jacobs

Pres., Morris Knowles Inc., Pittsburgh, Pa.

The Michigan Section committee report largely discards the theory of the demand or ready-to-serve charge but does, however, substitute a meter service charge. A review of the costs which the committee combines in order to determine the meter service charge reveals that some elements would also be included in the development of a demand or ready-to-serve charge.

In the author's opinion, a ready-to-serve charge is fair and equitable to all customers, since it represents a cost to the utility whether the water is used or not. This charge differs from what is commonly called a minimum charge in that all water used is paid for in addition, whereas the minimum charge permits the customer to use a certain amount of water before any further charge is made.

It is impossible to say definitely what part or percentage of the various classifications of operating expenses and fixed charges should be allocated to a ready-to-serve charge since each utility for which such a charge is to be established has expenses and conditions peculiar to itself. The determination of the demand charge is a matter of allocating all expenses, including depreciation and return on investment when applicable. A paper by Robert Nixon (1) has been quite helpful in fixing the allocation of the various costs to determine the basis for the demand charge.

Allocation of Costs

The cost of water works service can be divided into three parts: capacity costs, consumer costs and output costs.

The capacity costs are those of a system large enough and always ready to meet the maximum demand, while the consumer costs consist of the amount necessary to meet the expense of accounting, billing and so forth. The ready-to-serve charge is the total of both capacity and consumer costs. The consumer cost is easily determined and is generally recognized as embracing all those elements which vary directly with the number of consumers, but opinions differ on how to determine the capacity cost.

All expenses in connection with the source of water supply should be allocated to capacity cost. Pumping, purification, transmission and distribution expenses are allocated between capacity and output costs and should be determined in accordance with the conditions for the particular municipality or district served. All expenditures for maintenance and operation of service lines and meters, billing, meter reading, and consumers' accounting should be allocated to the consumer cost. General and overhead expenses should be divided among capacity, output and consumer costs as local conditions warrant. Fixed charges, such as depreciation, taxes and return on investment, should be allocated to capacity cost and output cost, but not to consumer cost.

The total consumer cost should be divided equally among all customers. The allocation of the capacity cost should be made on the basis of the demand which each customer places upon the water system. The Michigan Section committee discusses this allocation and states that there is no perfect method for assigning the capacity cost to the customers. Although there may be no scheme which does not involve some inequities, it appears to the author that the best method of allocation is to use meter ratios determined by a comparison of the squares of the diameters of the various meter sizes.

To summarize, a demand or ready-to-serve charge should be incorporated in any rate schedule. The determination of this demand charge should be made by allocating all operating expenses, depreciation, taxes and return on investment to three cost elements—capacity, consumer and output cost.

TABLE 2

Minimum Meter Rates

Ferrule Size *in.*	Meter Size *in.*	Minimum Yearly Rate	Water Allowed* *1,000-cu.ft. units*
½	⅝	$ 8	4
⅝	¾	12	6
¾	1	18	9
1	1¼	32	16
1¼	1½	50	25
1½	2	75	37
2	2	130	65
3	3	290	145
4	4	515	257
6	6	1,150	575
8	8	2,300	1,150
10	10	3,200	1,600
12	12	4,600	2,300

* All water in any year in excess of the quantity hereinabove fixed for any metered connection shall be charged for at the rate of 45¢ per 1,000 cu.ft.

The total of the capacity and consumer costs should constitute the demand charge, eliminating therefrom, of course, the amount which can be assigned against fire protection service. Within the ready-to-serve charge, the consumer cost should be divided equally among all the customers. The capacity cost should be divided among the customers on the basis of the squares of the diameters of the various sizes and quantities of meters in the system.

Application of Theory

In applying the above theory, actual practice has dictated the use of a "minimum" charge, embodying: [1] the ready-to-serve costs (capacity and consumer costs) and [2] a limited output cost for the first block of water use, which could also vary according to the square of the diameter of the meter. The new rates at Philadelphia exemplify this type of schedule, but variations were made in order to take care of local conditions which were given consideration in fixing the present minimum charges. Prior to 1947 meter rates at Philadelphia were based upon the size of the ferrule or corporation cock. For sizes up to 1½ in., it was customary to permit the meter to be the next commercial size larger than the ferrule. For 2-in. and larger ferrules, the size of the meter was generally limited to the size of the ferrule. On this account, the minimum charges were made proportional to the square of the diameter of the ferrule rather than the meter. Table 2 shows the size of ferrule, size of meter, minimum charges and quantity of water allowed for the minimum.

Reference

1. Nixon, Robert. Charges for Fire Protection Service as Determined by the Public Service Commission of Wisconsin. Jour. A.W.W.A., **29**:1837 (Dec. 1937).

Steps in Rate Schedules

Charles H. Capen

Chief Engr., North Jersey Dist. Water Supply Com., Wanaque, N.J.

In considering the important question of rate schedule slides (sometimes referred to as blocks or steps), most water works men have, until recently, leaned rather heavily on the 1923 A.W.W.A. and N.E.W.W.A. report (1). The increase in two-bathroom houses, garden clubs (with emphasis on lawn sprinkling) and air conditioning, together with the fact that many supplies are unable to expand to meet increased industrial demands except at great cost, makes further review of the question desirable. Whereas 25 years ago domestic needs alone were frequently around 30 gpd. per capita, the average today is generally somewhat greater. The author cannot find support, however, for the belief that the quarterly usage per household reaches the 20,000 gal. often used as a standard. With small business uses included, this figure might be approached, and for such an instance Melvin P. Hatcher has recently derived a figure of 21,000 gal. for Kansas City.

If, as is often claimed, the domestic and small business use should come within a slide that allows about twice the average use in this class, the upper limit would be somewhere around 40,000 gal. per quarter as compared with the 75,000 gal. advocated in 1923. Thus, by reducing the figure to 40,000 gal. but making the rate sufficiently high to take care of lawn-sprinkling use, the imposition of high demands during peak hours will pay for the extra capital investment needed to meet those demands.

Studies made by the author in 1939 show clearly that the cost of wholesale water (defined not as industrial water but as water delivered at the city or area limits, a variation being that when water is produced within

an area, the point of production governs) at that time was approximately $70 per million gallons and that $80–$100 should be taken as the cost figure over the long run in view of rising prices. In northeastern New Jersey, a large amount of water is sold at wholesale, the price ranging from $77.50 to $265 per million gallons. The bulk of it is sold for $85 to $90. Generally these prices represent the true cost of production.

The total cost in 1939 was found to be about 1.65 times the wholesale cost, a figure which is probably higher in 1949. A survey in 1944 showed an average ratio of residential *rate* to wholesale *cost* of 3 : 1, which comes quite close to substantiating the generalization that such an average should be expected.

By no means should it be inferred that industrial users should receive water at the wholesale cost. Rather they should pay that figure, plus the average transmission, distribution, meter-reading and overhead charges for such users. The obvious conclusion is that industrial users should actually pay somewhat more than one-third of the residential rate. By comparison, it should be noted that the 1923 report suggested a normal limit of 2 : 1 for the ratio of the domestic rate to the manufacturing rate, with a spread to a 3 : 1 ratio when four slides were used instead of three. Current practice and costs indicate that this suggestion was well taken.

To some extent, the foregoing is putting the cart before the horse, but it was felt advisable to express some of the basic ideas before getting down to facts on determining slides and costs.

If water served to industries costs, say, 33⅓ per cent as much as that served to residences, how can anyone justify ten more steps in between? Although there is no magical relationship between the 3 : 1 ratio of cost and the three slides (four, in extreme situations) recommended in 1923, this suggestion seems to have stood the test of time. Until proof to the contrary appears, the three and sometimes four steps are still recommended.

The nearest approach to a method of determining the number of slides would be to construct consumer and consumption curves, such as those used by electric utilities. An example has been given by Hatcher in which, if the 1923 committee report were followed, it would be found that a domestic-use slide of 0–25,000 gal. a month would include approximately 97 per cent of the customers, accounting for 87 per cent of the total domestic consumption. How can anyone justify a large number of slides for the remaining customers? It is believed that a nearly similar conclusion would be reached even if the consumption limit for the residential slide were much less, as herein advocated.

In many other respects, the author agrees with the report of the Michigan Section Committee on Water Rates. Separation of the fire charge is most commendable, but it is doubtful if the true cost will be met very often. It is, however, a most important step in the right direction.

In lieu of a service charge, a minimum charge will meet much less resistance. It is not logical, but much easier to explain.

To obtain the portion of costs chargeable to residential users, the cost of a system from which all fire protection costs have been eliminated would be computed. This is sometimes done by computing the size and cost of a system

which at no time would be required to furnish water for fire protection. Industrial use should also be eliminated. Then the overhead and operating costs attendant thereto would represent those costs assessable against domestic users. In effect, this procedure is quite largely what has been adopted in New Jersey in allocating inch-foot charges for mains and placing the balance of costs in the domestic bills.

Loveland (2) has given two methods for allocating fire service expense which are described as the surplus-capacity and the comparative-plant methods.

For determining the intermediate rate, the 1923 recommendation is still as good as anything yet presented. An exception might be made if an enlarged scale drawing of that particular portion of the consumer and consumption curves were constructed and a logical answer obtained therefrom. Otherwise, no good method can be offered.

At this point, the author would like to emphasize his belief that the domestic bracket is normally too large in scope—i.e., that 40,000 gal. per quarter would be more suitable than the 75,000 gal. advocated in 1923.

All of the foregoing is stated without stress on the lawn-sprinkling and air-conditioning demand. If these become a real problem in any one system, the statement of the late G. B. Schunke (3) may have to be accepted; namely, that there should be no reduction in rate regardless of the quantity used. In fact, it is reasonable to suggest that many cities will be forced to take the most unpopular step of placing a premium on sprinkling and air-conditioning uses.

Recently a roadside diner, on the outskirts of a city, put in an air-conditioning system. The first month's bill for water was $125, which was paid without a whimper. Apparently the patrons were pleased and the management satisfied. In the author's opinion, however, this practice is not good water business. (It should be noted that the city where this incident occurred was stretching its production facilities to the utmost to meet demands and was selling such water at practically cost, under conditions in which a little relief would have been appreciated.)

References

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Application of Michigan Section Committee Formula

Hal F. Smith

Sr. Admin. Asst., Dept. of Water Supply, Detroit.

To apply the Michigan Section formula to the Detroit Dept. of Water Supply costs, it was first necessary to classify under various headings the costs of operation and maintenance, debt service charges and the amounts expended or set aside for improvements and extensions. These classifications comprise: [1] commercial, [2] meters and services, [3] production, [4] transmission and [5] distribution—(a) mains 6 in. and smaller and (b) mains larger than 6 in.

This allocation of costs is by far the most difficult part of the application of the formula. Naturally, the degree of

difficulty encountered is dependent upon the classification of accounts used by the water department. Detroit's accounts are kept in accordance with the classification prescribed by the N.A.R.U.C. and readily provide most of the figures required—but, unfortunately, not all of them, making it necessary to estimate the distribution of some of the items. These estimates were based on all readily available information and are believed to be reasonably accurate. The details of this distribution are not included in this paper because of their length and because it would be difficult to follow them without reference to extensive explanatory notes. For the purpose of this paper, these details were not considered necessary, but they are available and will be furnished to anyone sufficiently interested.

It will be noted that this application of the formula does not cover the portion of the system used to supply water to suburban customers. Suburban water consumption and the costs pertaining thereto were deducted from system totals in order to arrive at a city rate.

Attention is also called to the fact that fire protection costs were not separately considered because the department receives no revenue for fire protection other than that produced by the water rates.

The application of the formula to Detroit costs is given in the Appendix to this paper. No attempt is made herein to justify or explain the theory of the formula since this matter is covered in detail in the committee's report (1).

Inasmuch as the formula does not provide definite rate step limitations, and because of other variables inherent in its application, there always remains the question whether or not the rate produced by the formula will yield the desired revenue. Since the formula rate steps do not conform to those of Detroit, no data are easily obtainable to show how much water would be sold at each of the step rates. It would be possible, of course, to break down the year's billings, or those portions considered necessary for a spot check, into the steps of the formula rate. This process is so time-consuming, however, that it was decided to make a check on the basis of average annual consumption by meter size. Because of the possible inaccuracies of such a test, it was first applied to water sales as billed under the Detroit rate. The revenue indicated by the test was found to be 92.5 per cent of actual revenue. The test was then applied to the formula rate, with this correction factor being taken into account.

Reference

1. Proposed Water Rate Schedule. Michigan Section Committee Report. Jour. A.W.W.A., **41**:209 (March 1949).

APPENDIX

Application of Proposed Rate Formula to Detroit Dept. of Water Supply (1947–48 Costs—City Users Only) *

TABLE 1

Distribution of Operation and Maintenance Expense, Debt Service and Improvements and Extensions to Formula Classifications

Classification	Expense	Classification	Expense
Commercial	$ 797,551	Distribution	
Meters and services	843,951	6 in. and smaller	$562,418
Production	4,282,975	Larger then 6 in.	707,898
Transmission	1,771,251		
	Total expense	$8,966,044	

TABLE 2

Computation of Service Charge

$$\frac{\text{Commercial costs}}{\text{No. of accounts}} = \frac{\$797,551}{336,508} = \$2.37 \text{ per account}$$

$$\frac{\text{Meter and service costs}}{\text{No. of meter units}} = \frac{\$843,951}{459,617} = \$1.84 \text{ per unit}$$

Meter Size *in.*	No. of Meters	Meter Cost Ratio	No. of Units	Charge per Size	Charge per Meter	Annual Service Charge
⅝	254,763	1	254,763	$ 1.84	$2.37	$ 4.21
¾	62,543	1.5	93,814	2.76	2.37	5.13
1	10,873	2.25	24,464	4.14	2.37	6.51
1½	3,482	4	13,928	7.36	2.37	9.73
2	2,438	6	14,628	11.04	2.37	13.41
3	977	10	9,770	18.40	2.37	20.77
4	521	20	10,420	36.80	2.37	39.17
6	593	35	20,755	64.40	2.37	66.77
8	272	50	13,600	92.00	2.37	94.37
10	29	70	2,030	128.80	2.37	131.17
12	17	85	1,445	156.40	2.37	158.77
Total	336,508		459,617			

* Does not include costs of ten-year extension program, which are incorporated in revised rate schedule effective February 14, 1949.

TABLE 3

Computation of Commodity Charge

Formula	Detroit Data		
Third Step			
$\frac{\text{Prod. cost + Trans. cost}}{\text{Pumpage (3rd-step base)}}$	Annual Pumpage—*1,000-cu.ft. units*		
	Total		17,346,126
	Municipal Use		
	Metered	438,067	
	Estimated	807,562	
	Suburban	2,977,606	
			−4,223,235
$\frac{\$\ 6{,}054{,}226}{13{,}122{,}891} = \$0.461/1{,}000$ cu.ft.	*3rd-step base*		13,122,891
Second Step			
$\frac{\text{Distr. cost (over 6 in.)}}{\text{2nd-step increment base}}$	Water Sales—*1,000-cu.ft. units*		
	Total		14,563,982
	Suburban	2,977,606	
	Wholesale	3,852,296	
			−6,829,902
$\frac{\$\ 707{,}898}{7{,}734{,}080} = \$0.092$	*2nd-step increment base*		7,734,080
$0.092 (2nd-step increment)			
0.461 (3rd-step rate)			
$0.553 (per 1,000 cu.ft.)			
First Step			
$\frac{\text{Distr. cost (6 in. or less) + Lost water cost}}{\text{Domestic sales (1,000-cu.ft. units)}}$	Water Losses—*1,000-cu.ft. units*		
	Main and service leakage		693,845
	Other losses		807,562
	Total		1,501,407
	@ 3rd-step rate		×$0.461
	Cost of lost water		$ 692,149.00
	Distr. cost (6 in. or less)		562,418.00
$\frac{\$1{,}254{,}567}{4{,}434{,}430} = \$0.282$			$1,254,567.00
$0.282 (1st-step increment)			
0.553 (2nd-step rate)			
$0.835 (per 1,000 cu.ft.)			

TABLE 4

Comparison of Formula and Actual Rate for Detroit

Step Rates

Step	Quantity per Month *cu.ft.*		Rate per 1,000 cu.ft.	
	Formula	Actual	Formula	Actual
First	first 3,000	first 10,000	$0.83	$0.78
Second	next 200,000	next 90,000	0.55	0.60
Third	over 203,000	over 100,000	0.46	0.48
Quarterly minimum	1,200	1,000	2.06	1.50

Monthly Service Charge

Meter Size *in.*	Formula	Actual	Meter Size *in.*	Formula	Actual
⅝	$0.35	$0.24	4	$ 3.26	$ 4.32
¾	0.43	0.36	6	5.56	7.20
1	0.54	0.72	8	7.86	11.04
1½	0.81	1.44	10	10.93	15.84
2	1.12	2.40	12	13.23	18.72
3	1.73	3.36			

Formula rate designed to produce annual revenue of $8,966,044.
Test (*see* p. 974) shows formula rate will produce revenue of $9,073,266.

This Month's Cover

The "big ones" from the Orange Reservoir in South Mountain Reservation, West Orange, N.J., aren't going to get away, but they are getting to go away. Following their removal from the reservoir by the state hatchery men pictured, they will be transferred to lakes at Branch Brook and Weequahic Parks in Newark. This project, carried out about once every three years, is designed to keep the fish population of the reservoir down to the desirable level for maintaining biological balance in the stored supply. Thus, for once, we told a fish tale (see P&R, p. 6) that we can prove. And we have the Newark *Evening News* to thank for evidencing our veracity, and broadcasting it too, in their edition of September 23.

Main Extension Problems in Indiana

By Fred R. Witherspoon

A paper presented on April 21, 1949, at the Indiana Section Meeting, Indianapolis, Ind., by Fred R. Witherspoon, Sr. Engr., State Public Service Commission, Indianapolis, Ind. This paper should be considered in conjunction with the report of the A.W.W.A. Committee on Water Main Extension Policy, published in the August 1949 Journal (Vol. 41, p. 729). The philosophy advanced by the author differs from that expressed by some state public service commissions. Although the A.W.W.A. committee does not see eye to eye with the author in many respects, at the same time his attack on the problem is realistic and gives consideration to a number of factors ignored by some commissions.

WATER utilities generally are seeking to expand and to add new business. The problem is to meet the extension requests and maintain these operations on a profitable basis. Most operators undoubtedly have on file a list of potential consumers wanting service, with a different set of conditions applying to each request. This paper will be limited to extensions made in the normal day-to-day operations of a utility in serving new customers and will not discuss major construction or improvement programs.

Commission Regulations

A large portion of the inquiries and complaints reaching the Indiana Public Service Commission pertain to the extension of various types of utility service to new patrons. Many of these potential customers mistakenly believe that the utility is obligated by the certificate of convenience or franchise held to provide them with a connection for service free of charge, regardless of the effect on the financial structure of the utility.

The Public Service Commission Act, as amended, contains the following provisions in Sec. 54–614:

> Every municipal council shall have power . . . to require of any public utility, by ordinance or otherwise, such additions and extensions to its physical plant within said municipality as shall be reasonable and necessary in the interest of the public, and to designate the location and nature of such additions and extensions, the time within which they must be completed, and all conditions under which they must be constructed, subject to review by the Public Service Commission. . . .

The Public Service Commission has over a period of years given the matter of reasonableness considerable study and has worked out some rules and standards of service for Indiana water utilities to follow. These regulations pertain to the minimum steps the utility is expected to take and do not prohibit any water system from adopting a more liberal procedure so long as no discrimination is practiced between customers whose service requirements are similar. The commission ruling divides the making of extensions into two groupings:

1. *Free extension.* Each utility should, upon written request for service by a prospective customer or a group of customers located in the same

neighborhood, make the necessary extension free of charge when the estimated total revenue for a period of six years from the prospective customer or customers is approximately equal to the cost of the extension, provided that the patronage or demand appears to be of such permanency as to warrant the capital expenditure involved.

2. *Extensions above free limit.* If the extension required in order to furnish service at any point within the corporate limits of a municipality, or for any adjacent suburb of a municipality, is greater than the free extension specified in the commission ruling, such an extension shall be made under the following conditions: the utility may require a deposit equal to the cost of the extension above the free limit and shall, for each additional customer connected within a period of eight years from the making of such extension, "refund an amount by which six times the estimated annual revenue of the new customer exceeds the cost of connecting such new customer, but at no time shall the aggregate refund made to any customer exceed the original deposit of such customer." A water utility may, however, provide an alternate plan to be approved by the commission if it desires to offer more favorable terms to prospective users, so long as discrimination between customers is not practiced.

If the extension is of such length, and the prospective business which may be developed by it is so meager, as to make it doubtful whether the business from the extension would ever pay a fair return on the investment involved, "or in the case of real estate development enterprises with slight or no immediate demand for service, or in the case of an industrial installation requiring extensive equipment with slight or irregular service, the facts shall be reported . . . to the Public Service Commission for investigation and determination as to the reasonableness of such extension or installation and the conditions under which it shall be made. The utility may require a written contract to be executed between the prospective user and the utility, setting forth all facts and agreements pertinent to the extension project."

The estimated cost of an extension shall be based on the diameter of the pipe to be used, but not, however, on a pipe diameter larger than 4 in., unless the actual consumption estimated for the proposed customer or customers requires a larger pipe.

Those water utilities, both municipally and privately owned, which understand thoroughly the minimum requirements of the Public Service Commission and adhere to them more or less uniformly experience the least difficulty and the best public relations in dealing with the problem of water main extensions. Privately owned utilities which are held to a more strict accountability by their stockholders are likely to be more cautious in making extensions that will not pay their own way. Water utility operations are a business, and sound business principles must be applied whether ownership is municipal or private, if nondiscriminatory service is to be rendered to all customers alike and the business is to remain solvent. It is well to remember that, when service is furnished at a loss by any solvent utility, the deficit is met by other customers using the service.

An attempt will be made to clarify some of the many inquiries about extensions that come to the commission. It is often asked how the total revenue for the six-year period should be determined in making free extensions. The minimum charge is the safer basis

for calculating anticipated revenue although the utility may exercise its judgment in using its own estimate of anticipated consumption and may guarantee itself by a written contract with the prospective customer. Likewise, whether usage will be sufficiently permanent to warrant the investment is a matter for the utility to judge, bearing in mind that no profit on the investment is likely to be realized until after six years. In making refunds for additional customers connected to extensions above the free limit, the utility invests additional money in the extension as more connections are made, which removes further into the future its recovery of the original investment. A continuous program over the years, however, will add revenue from extensions to plant built for the most part from the earnings thereof.

A major headache is often involved in the development of real estate subdivisions, industrial installations requiring a large investment with slight or irregular water usage, or other extensions of considerable length with little prospect of a fair return materializing. The latter include municipal requests for fire hydrant protection at isolated locations, a problem which will be discussed in more detail later.

Real Estate Developments

Real estate promoters and developers are an asset to any progressive community in providing areas for future growth, but they are likely to be aggressive in asking the water utility to extend service to undeveloped areas and they are reluctant to bear their portion of the financing. The reason is the painful interval—for them—that exists before the cost can be passed on to future lot buyers. Real estate men are born optimists and usually attempt to sell this optimism as a packaged article to the water works superintendent, who has never been able to pay an overdue invoice or meet a payroll with this kind of tender. It is a well known fact that public improvements like streets, sidewalks, sewers and utility installations enhance the value of real estate, to the owner's benefit. It would be as logical to expect taxpayers elsewhere in the corporation who have paid for their own streets to contribute for those in a remote subdivision as it would be to expect present water customers to pay for main extensions there. The civic development angle or intangible overall benefit to the community at large is often played up strongly but does not change the basic economic fact that a few benefit at the expense of the majority. Experienced developers of real estate projects expect reimbursement for all improvements in the sale price paid by future lot owners, the promoters bearing the expense until it can be passed on to others.

These real estate subdivision projects may be considered on the same basis as any others to which the ruling on extensions above the free limit may apply. Sometimes the utility may want to liberalize the minimum requirements cited above—for example, by extending the refund period beyond eight years in connecting new customers. It is well to remember, however, that after construction the utility takes over maintenance as well as ownership—the expense of which must be met although the revenue is negligible.

The actual experience of one of the largest municipal plants in Indiana, currently using a 25-year refund period, is of considerable interest. About 1926 some extensive real estate additions were promoted and main extensions were constructed, the revenue

from which was estimated to make refunds possible in an eleven-year period. In 1933, when the depression was acute, the city had a total remaining liability of approximately $170,000 on main extension refund contracts, with building construction at a standstill and with the liability of maintenance a considerable drain on all other plant operations. In 1939 a building boom started and refunds became due and payable, which the utility was hard pressed to meet. A ten-year liquidation period and the transfer of funds from current operating revenue were necessary to take care of this liability. After this experience the utility established its 25-year rule, but it still has a $22,000 refund liability on contracts with no time limit. Although a refund period of 25 years may work out for this particular utility, it is too long to be applied generally. More conservative opinion is that extensions which will not pay out in eight to twelve years are likely to be a liability rather than an asset.

Industrial Demands

Requests for extensions to serve industrial plants requiring a considerable investment with slight or irregular water usage are not uncommon. Canning plants that pack in late summer months when the pumping load elsewhere is at near peak, outlying factories, service stations and equipment salesrooms are some examples which may be noted. A current tendency to locate new enterprises at the outer borders of corporation lines increases the difficulty of working out water main extensions. Unfortunately, planners of new construction for business enterprises give only an afterthought to the necessity for public utility services and request them on short notice. More initiative by the water works in contacting such prospective users beforehand would help both the customer and the utility in working out all the details involved. It is well to explain to the prospective user not only his cost on the basis of extensions above the free limit, but the utility's cost as well and the unfair burden on existing customers unless the new user pays his just portion of the extension.

It is not unusual to receive a request for an extension of considerable length involving little prospect of a return on the investment. An example which comes to mind is a rather loud complaint recently received by the Indiana Public Service Commission. The complaining party had just completed a new filling station, located near the edge of a town of 943 population with a municipal water works which was experiencing some difficulty in making total revenue equal expenses. The prospective customer's location was approximately 1,500 ft. from an existing main, and there was little possibility of any other customers being added. The complainant wanted service immediately and was unwilling to stand any portion of the cost. On a free-extension basis, it would have required an estimated 60 years of gross revenue from this extension to recover the initial construction cost, exclusive of maintenance and service expense.

Hydrant Installations

Another problem experienced is the request of city or town officials for additional hydrant installations at isolated locations requiring main extensions. The anticipated hydrant rental charges are often entirely inadequate to warrant the expenditure requested. For example, a privately owned utility

in a town of 2,300 population, with a yearly rental of $60 per hydrant, has on file a long-standing request from the town board to install two additional hydrants that require a run of approximately 2,000 ft. of 6-in. main. At $120 a year, this investment, approximating $6,000, would require 50 years to recover, if no additional customers were connected. Hydrant installations requiring lengthy pipe runs with payment on a yearly rental basis will continue to be a problem, the logical and equitable solution to which is used by a few water utilities in Indiana, but not generally. If hydrant rental charges were contracted on an inch-foot basis for the mains involved, with a nominal maintenance charge annually per hydrant, main extensions for new hydrants would thus be on a mains rental basis, with a guaranteed return on the investment assured.

Conclusion

Water utilities provide a public service and should always seek to expand for the benefit of the community, providing adequate and satisfactory consumer service and fire protection. The service rendered and the methods used in extending it to new users should be nondiscriminatory for all customers. The cost of extensions should be borne by those customers who are to benefit, with provision made to apply the charges paid for water service over prescribed periods against the cost of the extensions. More uniformity among all water utilities in working out rules for extensions, with those prescribed by the Public Service Commission as a minimum standard, would make for better understanding and improved relations with all prospective users requiring main extensions.

Determination of Total Hardness in Water by Direct Colorimetric Titration

By J. D. Betz and C. A. Noll

Abstract of paper by J. D. Betz, Asst. Gen. Mgr., and C. A. Noll, Chem. Engr., both of W. H. & L. D. Betz, Philadelphia.

The authors, employing the principle of Biedermann and Schwarzenbach, have developed a direct colorimetric titration for the determination of total hardness. This new method is more accurate than the soap method and is considerably more rapid. Hardness values up to 1,200 ppm. can be titrated directly without dilution of the sample, with an accuracy within 2 per cent of gravimetric analysis. Low hardness values can be determined with an accuracy of 0.1 ppm. in the range of 0.0–2.0 ppm. hardness. The method is based on the titration of a water sample with an organic sequestering agent which will form un-ionized complexes with calcium and magnesium. The titration is performed in the presence of an indicator which is red in the presence of calcium and magnesium ions and blue in their absence. Possible interfering ions have been investigated and no interference is caused by ionic concentrations commonly encountered. The method has been tested in routine hardness determinations on approximately 9,000 water samples. JOURNAL readers may obtain a copy of the report of the investigations by Betz and Noll if they request it by writing to the Editor, JOURNAL AMERICAN WATER WORKS ASSOCIATION, 500 Fifth Avenue, New York 18, N.Y., enclosing a stamped (6¢), addressed envelope for reply.

Diversion of Water Department Reserve Funds

Panel Discussion

A panel discussion presented on May 31, 1949, at the Annual Conference, Chicago.

Wendell R. LaDue

Supt. & Chief Engr., Bureau of Water & Sewerage, Akron, Ohio

IN the past few years, it has become increasingly apparent that any water department which is efficiently operated so that it has surplus or reserve funds finds itself constantly on the defensive to protect those funds for their proper use. The appearance of a water department reserve or surplus often creates a desire on the part of fund-raising officials to divert such money from the water department to other uses. Those charged with the functioning of water works must make sure that funds are so allocated that their own departments are properly operated, maintained and extended.

"Diversion of water works funds!" To the old-time water works man, these were fighting words. To him, the "water works" was a sacred, continuing body, independent of the changing picture and the ordinary petty maneuverings of local politicians. Present-day water officials, however, with no less integrity than the old-timers, may be inclined to believe that the water works is a part of the municipal family and that it is proper to aid other members of the family, provided that the customers, who are supporting the water works, do not object to aiding the taxpayers, who support the rest of the family.

The provocative question is at once raised: "Is the water works manager unselfish enough to judge what is in the best interest of his department or city?" It may often be entirely proper and legal to divert utility funds for other city functions if the principle involved is distinctly understood by all and the utility law provides for sufficient protection and maintenance of the system by adequate financing.

Ohio Legislation

By way of introduction to the present discussion, a brief description of the history of legal diversion of water works funds in Ohio will be given.

During the depression, the Ohio legislature passed an act which, notwithstanding all other provisions of the state law, permitted the diversion of 3 per cent of the gross revenue of a water works to poor relief, disregarding the financial condition of the department, except its operating and debt charges. The use of water works funds for the feeding and housing of the poor is hard to justify. As was predicted, with the advent of better times, the desire for diversion persisted, even though the initial reason had been forgotten.

In 1943 the section of the General Code covering the disposition of water utility surplus was amended by the addition of this proviso:

Provided, however, that in those cities where water works and sewerage systems are conducted *as a single unit under one operating management* a sum not to exceed ten per centum of the gross revenue of the water works for the preceding year may be taken from any surplus remaining after all of the preceding purposes have been cared for and may be used for the payment of the cost of maintenance, operation and repair of the sewerage system and sewage pumping, treatment and disposal works and for the enlargement or replacement of the same, provided, however, that each year a sum equal to five per centum of the gross revenue of the preceding year be first retained from said surplus as a reserve for water works purposes.

This amendment was fostered by Akron officials and local state legislators, and most of the support for its passage came from this same source.

It is to be noted that the addition provides several pertinent features:

1. The new law goes further than the original statute by defining *"surplus"* as that portion of water revenue remaining after payment of the expenses of conducting and managing the water works, making repairs, enlarging or extending the works or the reservoirs and meeting the interest on any loan for their construction or for the creation of a sinking fund to liquidate the debt.

2. A water works reserve is provided for in advance of any diversion of funds for sewerage purposes. This reserve, which amounts to 5 per cent of the gross revenue and has first claim upon the water works surplus as defined, is an annual deduction and is cumulative. The water reserve from previous years is not used in the computation of any current year's surplus. The reserve may be expended, at the discretion of the service director, for water works repairs, replacements, new installations or extensions, either in lieu of bond fund expenditures or to provide carrying charges for such expenditures.

3. It is provided that 10 per cent of the gross revenue of the water works *may* be taken from this surplus, but only for the payment of the cost of maintenance, operation and repair of the sewerage system and sewage pumping, treatment and disposal works and for their enlargement or replacement.

4. The amended act further provides that before water works funds can be diverted for sewerage purposes, both the water works and sewerage systems must be conducted as a single unit, under one operating management. This qualification does not mean the management of the director of public service, but rather entails a *combined* operation under the management of a division head responsible to the director of public service. The sponsor of this amendment intended to make absolutely certain that proper operation of the water works would be amply provided for prior to permitting any diversion of water works funds. This safeguard has been incorporated in the act in the following sentence: "Ten per centum of the gross revenue of the water works for the preceding year may be taken from any surplus remaining *after all of the preceding purposes have been cared for.*" The term "preceding purposes" refers to the first portion of the act.

Attention is directed particularly to the "single unit" provision of the act, which permits maximum flexibility in the control of funds by the person in charge of combined operations of the water and sewerage systems and insures the proper usage of funds, thereby indirectly, but effectively, governing

and controlling the amount of funds available for surplus.

An immediate benefit of the "surplus" act resulted. The legislature, in proceeding to renew the act permitting 3 per cent diversion for poor relief if desired by a municipal council, included a provision that the total diversion of water works funds by legislative act for all purposes should not exceed 10 per cent of the gross revenue of a current year. Inasmuch as diversions for poor relief and for sewerage purposes are the only ones possible under existing laws, the legislature has cooperated to the extent of limiting all present diversion of water works funds to 10 per cent of the gross water works revenue. In those cities requiring and desiring 3 per cent for poor relief, only 7 per cent can be diverted for sewerage purposes.

Attention is further directed to the provision that, if the surplus, as above defined, is more than 15 per cent (5 per cent for a reserve water works fund and 10 per cent for diversion to sewerage purposes) of the gross revenue, then the amount in excess of the 15 per cent remains a part of the water works funds. Such excess can be used for any reasonable rate reduction plan which would in no wise restrict the efficiency of plant operations. These provisions will cause ill advised proposals for rate changes to receive very careful scrutiny before being presented. Any change tending to reduce or remove the surplus will eradicate the benefits derived from its use.

A somewhat backhanded assist in the conservation of water works funds may be found in the indenture covering water revenue bonds issued in May 1948. The one for a $4,500,000 issue for the Akron water works contains this paragraph:

Any balance remaining in the Water Works System General Income Fund at the end of any year, after making all the payments required by this Section 6, may be used for any lawful purpose, provided that the amount which may be transferred from any such annual surplus and used for any lawful purpose other than water works purposes shall be *limited to 50 per cent of such surplus* as may remain after: [1] First paying or making provision for payment therefrom of all debt charges on general obligation water works indebtedness of the City which accrued during such income year, and [2] Setting aside out of such surplus such amount as may be necessary to establish or maintain a reserve for repairs, enlargements or extensions of the utility equivalent in the aggregate to 2 per cent of the then total invested cost of the utility as shown by the records and accounts of the utility maintained in the City's Department of Public Service, and [3] Setting aside as an addition to such reserve an annual sum equal to 5 per cent of the gross revenues of the utility for such income year.

It should be noted that before any legal diversion can be made, a reserve of 2 per cent of the invested cost of the plant must be set up and maintained, and 5 per cent of the gross revenue for the year is also set aside. Further, only 50 per cent of the balance, if any, may be transferred. Assuming a $20,000,000 plant and a $1,500,000 annual income, it can be imagined how much will be available for transfer! Sometimes it pays to be in debt.

Questions Discussed

It is hoped that this panel discussion will answer some of these questions:

1. What are the existing practices and what does custom or precedent dictate?

2. Does there exist satisfactory enabling or restrictive legislation?

3. Is the trend toward more diversion or less diversion of water works funds?

4. Does there exist a clear definition of surplus, profits or reserves?

5. Are the needs of water works as going concerns protected so that they receive the funds necessary to keep them that way?

6. What is the effect of diversion practices on sound future planning?

E. Arthur Bell

Water Supt., Essex Fells, N.J.

As the diversion of water works funds is a very complex subject with many ramifications, the limits of this discussion should be stated at the outset. The basic assumption is that a reserve fund stems from the profit realized after meeting all normal expenses, such as operating costs, capital improvements and debt service. Obviously, also, the study is confined to publicly owned water supply systems, since private utilities dispose of their surplus in quite a different manner.

A study of practices in the East, including Delaware, New Jersey, New York and Pennsylvania, indicates that there is no uniformity of attitude on this all-important subject of reserve funds. Most states require municipalities and quasipolitical water groups to submit reports and records to the public utility commission in the same manner that privately owned utilities must, but otherwise public utility commissions have little or no regulatory power.

Because New York State has enabling legislation giving the public service commission power to treat publicly owned water systems in much the same manner as privately owned systems, most of the former are on a sound financial basis. New Jersey laws provide the state public utility commission with practically no control over publicly owned sytems but have furnished some degree of protection of funds through the director of the division of local government. This body has control over all municipal finances, including municipal budgets, both operating and capital. No municipality can function without the approval of budgets, audits and other financial matters by the director, and his jurisdiction includes the financial structure of the water department. In fact, most municipalities keep two sets of water accounts—one as prescribed by the director of local government and the other to conform to the rules and regulations of the public utility commission. This procedure is not as confusing as it sounds and seems to work out quite satisfactorily. In order for a municipality to transfer funds from water department surplus to the general account, approval must be obtained from the director. However, an amount in lieu of taxes or the like may be taken from the water utility and included as a receipt in the general account without formal permission.

Delaware has no regulatory body to guide and advise the municipal water departments. The late Richard C. B· ·kett, in his capacity as state sanitary engineer of Delaware, made a survey of the diversion of water works funds and learned that practice in this matter ranged from utilities that diverted no funds to the general account to one that turned over funds to the city and then showed a substantial operating loss on its books. As the details of Beckett's study have been published (1), they will not be repeated here. He

concludes, however, that water works funds should be protected against diversion to other municipal uses.

In Pennsylvania, the public utility commission has very little jurisdiction over the financial transactions of public water supplies, having only the authority to prescribe accounts and regulate reports (2).

Existing Practices

Existing practices of the systems covered by this report vary greatly—in fact, they run from the ridiculous to the sublime. On the ridiculous side are those systems which not only lack reserve funds but also draw on the general fund to remain solvent. These systems divert no funds and should review their management and rate structures without delay. Offsetting this condition are the highly efficient systems that turn over substantial sums without impairing their own needs, both for current operation and future planning.

These extremes, although interesting, are of little importance to the subject at hand, however, as this discussion is concerned primarily with the group that lies between. Usually those charged with the policy-making functions of a municipal water supply system are concurrently members of the governmental body. Exceptions include water supply districts, municipal water authorities and water boards which operate independently of the governing body and are composed of officials appointed by the state, county or municipality. Normally, municipal governing bodies, in preparing their annual budgets, divert water works surpluses as they please without consulting the management level of the utility, while water authorities and similar groups generally dispose of surplus as they see fit, but in accordance with the law.

In Pennsylvania, nearly all municipalities transfer surpluses to their general fund. During 1944 nearly 17 per cent of the total water works income was contributed to this account. In the same year substantial transfers were made, ranging from 8 per cent of the total tax revenue in Pittsburgh to 110 and 114 per cent in Lock Haven and Media, respectively (2). No figures are available for New York and New Jersey, but in discussion with various officials it has been learned that the diversion of surplus funds is a common practice.

Legislation and Diversion Trend

New York alone of this group has enabling and restrictive legislation, although, as previously mentioned, New Jersey's director of local government wields a big stick, particularly in restricting diversions. Trends toward diversion were found to be almost entirely a product of the economy of the country. At present high tax collections have reduced the need for bolstering the municipal income. Balancing this fact, increased operating costs, plant expansion delayed by the war and abnormal growth due to population shifts have reduced surpluses.

Definition of "Surplus"

A clear definition of surplus, reserves and profits does not exist in this area. The excellent discussion on the Wisconsin law by A. P. Kuranz (3) indicated the desirability for such regulations in the East, but at present the definition given in the opening paragraph of this paper will have to suffice.

Water Works Protected

Generally speaking, the needs of water works as going concerns are protected since they receive the funds necessary for continued operation, but there are instances on record in which the governing bodies, in order to show a low tax rate, have diverted not surplus funds but funds that should have been used for capital improvements and debt service. These same localities may be faced in the near future with the necessity of robbing the general fund to maintain the water department in a solvent condition. Naturally, sound future planning suffers under such treatment.

Summary

In summing up the findings of this study, several observations are offered:

1. Diversion of water department surplus funds is practiced widely.
2. No harm is caused by this practice when sound financial principles are used. Included in that category is future planning as well as current operation.
3. As costs—both operating and debt service—vary from year to year, it is not wise to embark on a rate-changing spree annually, and a sound diversion practice is a means of distributing the profit to the consumers, who may be compared to the stockholders of a private utility. An adequate rate structure is required, however.
4. Management officials are often at the mercy of government officials and have very little control over the use of surplus funds. This condition cannot be avoided if political expediency dictates the fiscal policy.
5. Regulatory powers vested in some state authority are essential and will deter unscrupulous use of surplus funds.

Acknowledgment

The author wishes to acknowledge the assistance of Charles Capen, Chief Engr., North Jersey Dist. Water Supply Commission, and Philip Potter, Public Utility Commission of New Jersey, in the preparation of this paper.

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John C. Detweiler

Mgr., Dept. of Water Operations, Metropolitan Utilities Dist., Omaha, Neb.

A survey was made to determine the experiences of various municipal water plant officials with the diversion or attempted diversion of water works funds in the midwest states of Kansas, Missouri, Nebraska, North Dakota and South Dakota. Water works officials or others in responsible charge of municipal water plants in twenty cities in the five-state area assigned were contacted and fifteen replies were received.

No attempt to define diversion was made, although there appear to be two general methods by which actual or potential funds are diverted. The first method, which is quite general, involves the renunciation of potential revenue from water for public use, including street, sewer, park and fire departments and the public schools. The

second method is the actual transfer of cash or reserve funds from the water department to other municipal agencies. It is assumed that this survey applies principally to reserve funds.

Three specific questions were posed to these water officials, in addition to a request for a brief report of their experiences with the diversion of water works funds for other public uses. The questions were:

1. Is the legislation controlling your operations satisfactory from a financial standpoint?
2. Have funds actually been diverted to other functions of city government?
3. If water revenues have been diverted, does the water department have sufficient funds for needed improvements?

The responses to the questions submitted did not indicate a serious condition involving the diversion of water works funds in this five-state area. Only one official, in South Dakota, stated definitely that legislation was deficient and that the operation and expansion of his water plant was affected by the diversion of funds to other city functions. Several officials indicated that diversion had been attempted in prior years but that present operations were carried on strictly in accordance with existing laws.

South Dakota

South Dakota laws require all water department income to be paid into the general fund which supports other municipal functions. According to one water official from that state, "It would be better if all water works income were placed in a separate fund and all expenditures were entirely separate from the general fund."

Kansas

In Kansas the statutes control diversion by the following section (13–2408):

Deposit and use of revenue; transfer of moneys, when. All revenues from the sale and consumption of water and from the management and operation of water works, shall be deposited daily, in the city treasury to the credit of the water works department, and be kept in a separate fund, to be known as the water works department fund; and such revenues shall be used exclusively for the operation, maintenance, renewal and extension of the water works, and in paying off the bonded indebtedness created for the purchase price thereof, or interest charges on such indebtedness, and for no other purpose, except, it shall be lawful for the Board of Commissioners in cities of the first class having a population of less than 25,000 inhabitants, to use any surplus that may accumulate in said fund for the purpose of purchasing equipment and appliances for the fire department of such city.

Provided further, In cities of the first class having a population of more than 60,000 and less than 90,000, the governing body thereof may transfer funds from the water department to pay (a) the principal and interest on all bonds issued under section 13–808, General Statutes of 1935; (b) the pensions of former employees of the water department. Any member of the Board of Commissioners who shall vote for, or aid, in the transfer or use of such revenues for any private purpose or for any other department of the city government, except as herein provided, shall forfeit his office and be liable on his official bond for such misappropriation.

Nebraska

Several of the municipal water plants in Nebraska are operated by a board of public works, under whose adminis-

tration the disposition of water funds is well controlled. When bonds have been issued for water works improvements the bond indentures more or less limit any diversion of funds.

Lincoln, Neb., has a definite provision in the city charter preventing diversion of funds. The Metropolitan Utilities Dist. of Omaha, with control vested in a board of directors and general manager, is operated separately from other city functions and is under separate statutory regulation. Revenues, expenditures and the establishment of water rates for the water department are under the control of this group.

Missouri

Kansas City, Mo., reports that its charter sets water department funds and operations apart from those of other city departments. The charter reads, in part:

> All revenue and income derived from the water works, after paying all operating expenses, all maintenance and repair charges and all costs due to obsolescence or other cause, shall be first applied to payment of interest on bonds outstanding for water works purposes insofar as may be necessary, and the balance thereof shall go to a sinking fund which shall be established to meet the principal of said bonds, or for enlargements, extensions and betterments as the Council may by ordinance provide.

From St. Louis it is reported: "We have not increased our charges for water since 1918, but during the past thirteen years we have been able to accumulate $10,400,000, and at the present time have a $14,000,000 surplus in water works revenue." Evidently the diversion of surplus water works funds in this city is under control.

Conclusion

The author observes from a study of the replies received in this survey that cities having the most difficulty with the diversion of water works funds are those where the revenues from water works operation are paid into a general fund and expenditures are allowed against this fund for the operation and betterment of the water works property, but not necessarily on a balanced basis. Where the water works operations are carried on under a board separate from other city functions, the water works funds appear to be under control.

C. M. McCord

Director, Water Div., Light, Gas & Water Div., Memphis, Tenn.

This discussion is limited to conditions in Alabama, Kentucky, Mississippi and Tennessee, in which states key personnel provided sufficient information to indicate that existing practice follows no particular pattern and varies from one extreme to the other. The matter of custom or precedent seems to be less significant than the immediate requirements of the community.

Inasmuch as reserve funds are treated in so many different ways, the indications are that there is usually no restrictive legislation, or only that incidental to prescribing financial procedures.

The trend in regard to diversion of water works funds was summarized by one official thus: "I believe there is a slight tendency toward less diversion of water works funds. This nation has come more and more to demand excellent water supply systems, and I believe that the importance of water sup-

ply is more fully recognized by the public—so much so that officials are more inclined to treat the municipal departments as separate utilities." In addition to this statement, others indicated an improvement in this matter. One should not conclude from this discussion that serious diversion of funds is always practiced. For example, one superintendent reports: "All of the money collected by the water bureau is used solely for the benefit of the bureau, and we receive no aid from any source other than water revenue. We pay into the general city [fund], in lieu of taxes, 12 per cent of our gross, and, in turn, the city and all its branches are treated as any other water customer and are paid for services on the same basis."

It is considered safe to say that water works, generally, receive necessary funds to keep them operating as going concerns, but too often relief comes too late and is insufficient for the best interest of the water department.

Water works men generally agree that when a department is allowed to retain its receipts it can plan and organize its program from year to year systematically and to the benefit of the community it serves.

The author believes that this problem must be settled on a local level, as it has many complicating features. In some localities, water departments are combined with electric, gas and sewer facilities. Some communities have a tax rate as high as the law allows and yet require more funds, making it difficult for those in charge to overlook any means of obtaining revenue. It would seem, in the light of the present tendency of the public to require more and more of city governments, that the changing personnel who constitute city management will continue to canvass all possible sources of revenue for operating funds.

In the interest of the public and the water departments, water works personnel should stress the necessity and importance of an abundant water supply, carefully maintained, generously equipped, efficiently staffed, and financed in such a manner that the utility can both plan and build in advance of actual load requirements.

Albert R. Davis

Supt., Water Dept., Austin, Tex.

A survey of the Southwest Section, comprising the states of Arkansas, Louisiana, Oklahoma and Texas, indicates that diversion of water works funds to other city departments is more the rule than the exception. From the viewpoint of those opposing diversion, there exists no satisfactory enabling or restrictive legislation in any of the four states. It is not practical to attempt a digest of the state laws in this discussion. Generally speaking, there is a wide range of statutes covering this particular problem, all of which have been enacted under a representative form of government and have the usual amount of human vagaries in them. Court rulings in specific cases indicate a normal number of loopholes.

An abbreviated excerpt from the Texas Law covering diversion of funds in the event of a bond issue reads:

> Whenever the income of any . . . water . . . system . . . shall be encumbered under this law, the expense of operation and maintenance . . . shall always be a first lien and charge against such income. Provided, that only such repairs and extensions as . . . are necessary to keep the plant . . . in operation and render

adequate service, or such as might be necessary to meet some physical accident . . . which would otherwise impair the original securities, shall be a lien prior to any existing lien. The rates charged for services . . . shall be equal and uniform, and no free service shall be allowed except for [the] city, public schools . . . and institutions operated by such city.

No part of the income of any such system shall ever be used to pay any other debt, expense or obligation of such city, except payments made in lieu of taxes, until the indebtedness shall have been finally paid.

(Rates shall be adequate.)

It will be noted that schools and institutions operated by the city have been excepted and allowance has been made for a tax equivalent.

Trend Toward Diversion

In all four states the trend is toward more diversion of water works funds. The cost of materials and labor for all municipal activities has risen so sharply in the last few years that city officials have been hard put to find sufficient funds to maintain a standard of service that would receive public approval. Surplus funds accumulated during the war years offered an opportunity to make ends meet. The "blueprint now" campaign, carried out during the war in anticipation of a work shortage that has yet to develop, played its part in the diversion of funds. Immediately following the war, plans were pulled off the shelf because funds had accumulated and the people were restless and wanted things done. The water works plans were included in the list, but because of shortages of materials and labor they could be only partially carried out. The net result was that streets, bridges and the like were given the "go" sign. Many small cities and towns are finding that it is a lot less painful to collect utility funds monthly than to collect taxes annually. A number of towns owning their water, light, gas and sewer systems have been able to eliminate taxes entirely.

Water Works Protected

Water works in all four states are receiving the funds necessary to maintain them as going concerns. The Southwest is highly conscious of the need for adequate water supplies, and when occasion demands it, the electorate will vote bonds and obligate its last shirt to get what is needed. There is a keen distinction between the "needs" of a plant and its "wants," but as far as the essential "need" is concerned, there is no reason to worry about the electorate supporting the water works.

Planning in itself is not "too expensive" an operation. Where funds are diverted, there is a fertile field for the engineer with a desire to guess what will happen during the next 25 years. It has been the author's experience that a well laid out program for distribution and plant improvements is a top selling argument for a department to use its own surplus funds.

Conclusion

As Americans, water works men believe in American business practices, in majority rule and in the democratic principles of government. In a municipally owned water department, the customers or the electorate, or both, are the stockholders. The city council or other governing body is the board of directors. An electorate, through the board of directors, has the power to dictate the manner in which all funds are handled. If the electorate desires to pay part of its taxes by paying more for water, then, according to democratic principles, it is incumbent upon water

officials to follow that dictate. Professionally, water officials are duty bound to make it clear to the electorate, through reports and other methods at their disposal, what part of the dollar is going to purposes other than water. The diversion of funds without full accounting is little short of criminal. The electorate is entitled to know how its business is being handled by its board of directors.

From the standpoint of a water works official, it would appear easier to use water department surpluses for making extensions to plant and system, but again it must be asked, "Is this a purely democratic procedure?" When a business concern needs money for plant improvements or extensions, it issues new stock to provide the funds. For a municipal water works, general-obligation and revenue bonds are used to secure funds for improvements. The term "improvement" implies new customers added to the system, and they, in turn, help to repay the cost involved. If reserves are allowed to accumulate, the new customer is added to the system at the expense of the old ones.

D. D. Gross

Chief Engr., Board of Water Commissioners, Denver, Colo.

The area covered in this report includes Arizona, Montana, Colorado, New Mexico, Utah and Wyoming.

Montana

In Montana, the activities of the municipal utilities are controlled or supervised by the Board of Railroad Commissioners, *ex officio* public service commissioners of Montana. The actual operation policies of the water utility, however, are usually directed by the city mayor and council. Thus, with the Public Service Commission stating what cannot be done, and the city council stating what must be done, the water works officials of cities in Montana must be men of stamina.

The commission provides a system of accounting by which water works funds must be kept separate from general city funds and may be used for operating, maintenance, interest and bond retirements, and general water works improvements. There is a stringent regulation, however, that such funds cannot be used for the extension of mains. The cost of installing water mains (aside from main distributors) must be paid for by abutting property owners.

Sinking funds may be accumulated to meet reasonable anticipated needs, but this money cannot be transferred for general city use. This regulation has been circumvented in the past, however, by borrowing the funds, with repayment sometimes indefinitely postponed. Methodical water works officials have found it desirable to invest the funds set up for depreciation in government securities, because it is not so easy for the city council to borrow invested funds as it is to borrow cash. Some of the Montana municipalities, however, have plants free from debt. The Public Service Commission proposes that water works funds be administered for the benefit of the water users and not for the benefit of taxpayers.

Arizona

In Arizona, the situation is quite different. It is considered the proper procedure to use surplus water works funds to relieve the tax burden. Budgets for the needs of the municipal water plant are set up along with other city expenses. Although money may be held out for retirement of bond is-

sues, in general the funds received go into the city treasury, and, if for accounting purposes they are kept separate, it is a rule that at the end of the year any surplus is paid into the general fund.

One city of less than 45,000 population expects to turn over $300,000 from the water fund to the general fund in the fiscal year 1948–49, a little less than half of the total water works revenue. Admittedly, this procedure places the water department in a bad situation when emergencies arise. As it is difficult to get the money for major, and some minor, improvements, it is usually necessary to float a bond issue.

Rocky Mountain Section

Throughout the states in the Rocky Mountain section, the general practice is to keep water works funds intact and in a separate account, although there are a number of exceptions. These funds can usually be diverted or borrowed at the discretion of the city government. There are a few water departments in this area in which the revenues collected do not pay the expenses, and assistance must be secured when budgets are being prepared, drawing money from other sources. Several cities (mostly small) whose water plants are paid for feel that not much in the way of reserve funds is required. In fact, one of these cities makes the customers Christmas presents of the December bills.

In a few cities, including some of the large ones, the water plant is administered by a board wholly independent (or nearly so) of the rest of the city government. Sometimes sinking funds and surplus monies are invested in improvements, but sufficient funds are reserved to meet emergencies. In some of these cities, the water rates are set up to supply the necessary funds for operation, maintenance, bond retirement, interest and part of the improvements, but usually a major improvement program requires a bond issue.

It is believed most desirable for the operation and finances to be kept separate from the rest of the city government. At best, the water department is a public utility and not a government function. It is entitled to receive compensation for all service which it renders, both public and private, and in justice to the water customer, it should receive it. The water department cannot equitably collect money from one body of citizens and make donations to another, and perhaps different, group of citizens. Although the people must use water, and pay for it directly or indirectly, the benefits which they may individually derive from public schools, parks, streets and other city departments may not be—and, in fact, seldom are—in the same ratio as their water bills. The benefits from the activities of other departments of the city government are more correctly reflected in taxes than in water bills.

W. C. Morse

Supt., Water Dept., Seattle, Wash.; died Sept. 21, 1949.

In approaching the subject of the diversion of water works funds, a wide divergence of opinion is encountered. One school of thought believes that any municipally owned utility should be run at the least possible cost, with the rates so regulated that the revenues will cover the bare cost of operation, including interest, servicing of bonds and depreciation. If there is any surplus above the amount required for operation, the rates should be reduced.

Another school of thought holds that a utility which is municipally owned

should be handled exactly in the same manner as though privately owned, with all surplus over and above the cost of operation—including interest, taxes, depreciation and bond retirement—being returned to the general fund, just as if it were a dividend to owners of a privately owned utility.

Generally speaking, if rates are established to provide only the bare cost of operation, including depreciation and debt servicing, the water department has difficulty in getting sufficient revenues to permit extensions, betterments and replacements, with the normal result that the utility is unable to progress and to take advantage of many opportunities to reduce operating costs.

Seattle operates under the second plan, but the city charter provides that "The transfer of surplus funds from a city-owned public utility, or the collection of any tax from such utility, shall not be permissible until ample provision has been made for the servicing of the debts and obligations of the utility, and for necessary betterments and replacements, for the current year."

The Washington State Supreme Court has held (55 Wash. 86) that in its proprietary position, a city (Spokane) had the right to raise water rates so long as they were not exorbitant.

If rates are set to produce revenue sufficient to carry the department in all its phases and still leave funds for diversion to the general fund, there can be no objection at all to such diversion, from the department's standpoint. In this instance, what really happens is that the department simply becomes a collection agency for a "hidden tax" which is a part of the water rate and is paid by the water customer.

The freedom to establish rates is sharply curtailed by the desire to keep water rates in any particular city on a competitive basis with other cities of proportionate size in the surrounding area.

In Seattle, the diversion of water department funds was first put into effect by an exceptionally heavy occupation tax of 6 per cent on gross revenues received from customers within the city.

The next tax of real moment was the so-called sewer service tax, which was determined upon by the city council as necessary because at that particular time, 1938, warrants of the city, other than those of the water department and the light department, were carrying a sharp discount. In order to bolster the general fund revenues by a considerable amount, it was decided to raise approximately $576,000 a year through an increase in water rates to cover a sewer service charge. It was determined by calculation that this amount of excess revenue could be obtained by raising the rates approximately 38 per cent on an average and the new rates were put into effect in July 1938.

This sewer tax diversion was anticipated to last for only two years, but, as is quite common with a tax once established, it is difficult indeed to return to the former status, and the sewer service tax is still in force.

Year by year as revenues increased, the net profit of the department rose considerably, even after the diversion of $576,000 was made to the general fund. Of course, this fact did not escape the attention of the city council, and additional diversions were made. As a result the department became afraid that the division of profit between it and the general fund would be such as to leave the department without sufficient funds to pay for the necessary extensions and betterments on a cash basis.

It was finally agreed that a formula should be worked out permitting the diversion into the general fund of an amount equivalent to 38 per cent of the revenue which would have been raised without the addition of the 38 per cent increase in rates. This percentage reduces to 27½ per cent of the surplus shown by the department over and above its operating and financial requirements and after deducting the $576,000 from the surplus.

For the past several years this formula has worked out in a very satisfactory manner because it gives to the general fund just slightly more than is brought into the department by the increase in rates and still leaves the department with only slightly less surplus to plow back into the system than it would have had if there had been no diversion and no increase in rates.

It was possible for Seattle rates to be raised, as they were in 1938, without increasing the selling price of the water to an amount beyond that paid in other cities and towns of the Northwest, and Seattle's domestic rates now are very largely parallel with rates charged elsewhere.

The diversion of a portion of its earnings to the general fund of the city has worked no hardship upon the Seattle water department. During 1948 the department paid into the general fund $1,023,483.47, divided thus: city utility tax, $116,768.09; general fund services, $45,030.00; sewer service tax, $576,000.00 plus $285,685.38 as a special assessment. The department also paid a state utility tax of $71,394.55, making a grand total of $1,094,878.02, or 34.25 per cent of gross income paid out for taxes and special assessments. In the past ten years there has been diverted to the general fund of the city $9,230,000, or 32.67 per cent of the gross revenue of the water department. This diversion was entirely covered by the increase in rates, which was designed to raise funds for general city purposes but was actually nothing more than a collection made by the water department for the general fund.

Hidden Diversions

Many diversions can be made from water department funds by underallowance for parks, fire hydrants, street flushing, municipal buildings and general municipal purposes. Diversions of this nature are harder to segregate and show directly as costs to the department than are straight transfers of water department funds to the general fund.

The department should constantly insist that hidden diversions of this type be avoided. It is far better for the department and much better business accounting if prescribed rates apply to all users. If, as a result of charging certain fixed rates for water used for municipal purposes, there should be an addition to the net profit of the department beyond its requirements, then either a direct diversion to the general fund or a reduction in rates can be made. Certainly no city department charged with the actual amount of water used will let it run to waste as it will inevitably do if water costs the department nothing.

Another side of the picture is the fear expressed by some that the freedom to divert water department funds into the general fund is a standing invitation to increase rates in order to obtain more money for general municipal purposes. This fear may sometimes be well founded, but in the background is the protection afforded to the people by the right of initiative, which will always be a safeguard against the establishment of unjustifiable practices in the diversion of department funds.

Municipal Water Use in the United States

By W. B. Langbein

A contribution to the Journal by W. B. Langbein, Hydraulic Engr., U.S. Geological Survey, Washington, D.C. *This analysis of water use in American municipalities is based on data presented in the U.S. Public Health Service "Inventory of Water and Sewage Facilities in the United States, 1945."*

ACCELERATING demands for water by cities are beginning to add up to a significant load on the water resources of the United States. In many parts of the country, the total use of water—stepped up during the war, when new loads were thrust upon old systems of supply—is reaching physical or economic limits. Although figures are not available, there is substantial evidence that the domestic and industrial use of water has increased still further since the war. Water for life and health, as served by the water works industry, doubtless should have the highest claim on the nation's water resources. Evidence indicates that the use of water by municipalities tends to show a greater rate of increase than all other uses. Many areas of conflict between competitive uses of water may therefore be expected as the demands for water for all purposes continue to increase.

Lack of data has been a handicap in appraising the magnitude of water utilization. Recently, however, two useful compilations have been published. One is the A.W.W.A. "Survey of Operating Data for Water Works in 1945" (1). The second is the U.S. Public Health Service "Inventory of Water and Sewage Facilities in the United States, 1945" (2). Although these two reports are incomplete, because data are either inaccurate or are missing for a large number of cities, the available information, supplemented by estimates when needed, shows that in 1945 over 70 per cent of the people of the country lived in communities served by public water supplies. Every day these water supply systems furnished an average of 12 bil.gal. of water for domestic, municipal and industrial needs.

TABLE 1

Comparison of Population and Water Use Increase

Item	1890*	1945†
No. of water works	1,878	15,400
Population served	22,800,000	94,390,000
Per cent of U.S. total	36	71
Avg. per cap. use—*gpd.*	90	127
Total estd. U.S. use—*mgd.*	2,050	12,030

* Based on Turneaure and Russell data (3).
† Based on analysis of U.S.P.H.S. inventory (2).

Comparative Statistics

Table 1 shows a sixfold increase in total water use from 1890 to 1945, com-

TABLE 2

Summary of Water Production for Public Use, 1945 *

State	Average Total Plant Output—*mgd.*				Percentage of Plant Output			No. of Units Using Each Source				1945 Population		Avg. Use Per Capita Served *gpd.*
	Streams, Lakes and Reservoirs	Wells	Springs	Total	Streams, Lakes and Reservoirs	Wells	Springs	Streams, Lakes and Reservoirs	Wells	Springs	Total	No. Served	U.S. Census Estimate	
Alabama	91	30	18	139	65	22	13	66	144	48	258	1,427,388	2,696,000	98
Arizona	4	47	2	53†	7	89	4	9	60	18	87	256,095	570,000	206
Arkansas	25	22	2	49	51	46	3.3	32	130	12	174	648,989	1,829,000	76
California	774	481	12	1,267†	61	38	1	135	350	20	505	7,924,359	9,073,000	160
Colorado	146	18	3	167	88	11	1.5	104	93	24	221	814,805	1,071,000	206
Connecticut	180	5	2	187	97	2.5	0.8	97	59	11	167	1,689,474	1,747,000	110
Delaware	15	9	0	24	64	36	0	3	51	0	54	209,569	273,000	117
Dist. of Columbia	180			180	100			1	0	0	1	892,000	880,000	201
Florida	27	108	0.7	136	20	79	0.5	24	276	2	302	1,435,440	2,294,000	94
Georgia	95	37	3	135	70	27	2.4	78	219	32	329	1,242,435	3,040,000	109
Idaho	30	29	5	64	47	46	7.4	46	84	40	170	296,882	522,000	215
Illinois	1,104	122	0.2	1,226	90	10		150	602	4	756	6,336,954	7,521,000	193
Indiana	159	111	2	272	58	41	0.7	46	291	4	341	2,112,051	3,484,000	129
Iowa	35	86	.5	121	29	70	0.4	38	587	5	630	1,456,747	2,400,000	83
Kansas	66	73	1.3	141	47	52	0.9	61	330	6	397	1,071,788	1,793,000	131
Kentucky	88	9	1.5	98	90	8.7	1.5	115	123	19	257	1,117,206	2,568,000	88
Louisiana	93	51	0	144	64	36		27	188	1	216	1,401,729	2,405,000	103
Maine	78	9	1	88	89	10	1.2	98	41	21	160	644,418	801,000	136
Maryland	137	17	1.3	155	88	11	0.9	32	127	23	182	1,458,949	1,979,000	107
Massachusetts	310	61	1	372	83	16	0.3	95	158	12	265	4,196,544	4,166,000	89
Michigan	381	99	0.6	480	79	21	0.1	73	350	6	429	3,846,244	5,425,000	125
Minnesota	89	52	2	143	62	36	1.5	31	463	10	504	1,613,623	2,625,000	89
Mississippi	10	45	0.8	56	18	80	1.3	4	234	11	249	636,000	2,131,000	88
Missouri	273	36	0.1	259	86	14	0.1	62	299	3	364	2,416,505	3,600,000	107
Montana	54	15	6	75†	71	20	8.3	45	66	15	126	317,891	446,000	237
Nebraska	30	79	0.8	110	27	72	0.7	7	395	8	410	717,795	1,230,000	154

* Based on U.S. Public Health Service inventory (2).
† More than one-third estimated.

TABLE 2 (*contd.*)

State	Average Total Plant Output—*mgd.*				Percentage of Plant Output			No. of Units Using Each Source				1945 Population		Avg. Use Per Capita Served *gpd.*
	Streams, Lakes and Reservoirs	Wells	Springs	Total	Streams, Lakes and Reservoirs	Wells	Springs	Streams, Lakes and Reservoirs	Wells	Springs	Total	No. Served	U.S. Census Estimate	
Nevada	19	12	4.5	36	54	34	12	8	16	15	39	80,529	140,000	447
New Hampshire	22	8	0.4	31	74	25	1.2	65	31	13	109	369,215	466,000	83
New Jersey	260	142	3	405	64	35	0.8	41	209	17	267	4,110,823	4,112,000	98
New Mexico	9	34	2	45	21	75	4.4	12	90	6	108	289,795	515,000	155
New York	1,432	211	21	1,664	864	13	1.2	377	350	207	934	12,391,125	12,839,000	134
North Carolina	142	17	2.4	162	89	10	0.5	129	177	20	326	1,360,600	3,514,000	119
North Dakota	8	6.5	0.1	14.6	55	44	0.7	15	108	3	126	201,247	510,000	72
Ohio	412	129	0.3	541	76	24	0.1	108	390	17	515	5,098,681	6,873,000	106
Oklahoma	78	28	5	111	70	25	4.6	86	238	10	334	1,132,489	2,195,000	98
Oregon	102	23	9	134	76	17	6.6	117	113	50	280	932,024	1,311,000	143
Pennsylvania	915	65	29	1,009	91	6	2.9	400	325	250	975	8,148,663	9,352,000	124
Rhode Island	53	3	0.05	57	94	6	0.1	20	39	3	62	731,778	735,000	78
South Carolina	64	12	2	78	82	16	2.8	75	143	10	228	785,089	1,909,000	100
South Dakota	6	15	4	25	24	60	15.4	16	169	14	199	267,845	539,000	92
Tennessee	77	37	16	130	59	28	12.1	41	112	93	246	1,265,105	2,817,000	102
Texas	184	224	4	413	45	54	0.9	165	768	12	945	4,126,046	6,708,000	100
Utah	19	34	41	94†	21	36	44	24	25	163	212	478,779	597,000	197
Vermont	17	2	9	28	62	7	31	48	16	95	159	206,680	325,000	134
Virginia	181	7	13	201	90	3.5	6.4	113	184	107	404	1,550,035	2,935,000	130
Washington	295	103	14	412	22	25	3.5	109	183	63	355	1,505,089	2,175,000	274
West Virginia	41	18	4	63	66	28	5.7	148	333	34	515	966,965	1,696,000	65
Wisconsin	124	83	2.3	209	59	40	1.1	32	361	17	410	2,045,151	2,935,000	102
Wyoming	10	13	4	27	38	46	16	24	36	8	68	148,041	252,000	183
United States	8,902	2,874	256	12,032	74	24	2	3,652	10,136	1,582	15,370	94,392,039	132,019,000	127

† More than one-third estimated.

pared with a twofold increase in the population of the country and a fourfold increase in population served by public supply systems.

The American people are accustomed to the liberal use of water, and its consumption is increasing, along with the trend toward urbanization, in order to meet the needs of increased industrial production and improved health standards. More families than ever before in the United States have bathrooms and washing machines. New water-using devices, such as automatic dishwashing machines and garbage disposal fixtures, are appearing in the kitchen in increasing numbers. Industry demands more water for expanding production and also uses more water per unit of product to achieve greater efficiency of operation. Air conditioning of factories, offices and stores is quite common. A generation ago 100 gpd. per person was considered a fair average for the use of water in American municipalities. But the increased use of water in homes and factories and for street cleaning and lawn sprinkling has raised this figure to a general average of 127 gpd., and to more than 300 gpd. in many of the western communities.

In addition to the increase in per capita use, the most striking part of Table 1 is the near doubling of the percentage of the population served. A portion of this increase is due to the general long-term trend toward urbanization (in 1890, 28 per cent of the population lived in communities of 10,000 inhabitants or more, in contrast to 48 per cent in 1940), but another significant factor is the development of water works in a host of small communities. So large has the number of plants become that the average output of water works has actually decreased from 1.1 mgd. in 1890 to 0.8 mgd. in 1945, despite a marked increase in the capacity of nearly all plants existing in 1890.*

Analyzing the sixfold increase in aggregate demand since 1890, it is found that the increase in total population represents a factor of 2.1; the increase in percentage served, a factor of 2.0; and the increase in per capita use, a factor of 1.4.

1945 Output

A state-by-state summary of the aggregate output of water by municipal water systems, as obtained from the two sources previously cited, is given in Table 2.

The last column of Table 2 gives the per capita use of water in each state. The per capita use of water in individual cities varies greatly from the nationwide average of 127 gpd. for reasons which are not always apparent but which probably reflect one or more of the following causes: [1] inaccurate data; [2] portion of production sold at flat rates (most common in areas of abundant supply); [3] variation in per capita income and living standards; [4] development of private supplies by industry; [5] size of city; and [6] variation in extent of lawn sprinkling. The last is widespread in some western cities, especially Boulder City, Nev., where the per capita use is over 500 gpd. Some western communities, however, use ditch irrigation diverted from farm canals. Small-unit evaporating

* Almost 80 per cent of the U.S. communities served by public water supplies have a population of less than 2,500 persons. Consequently, when a simple arithmetic average of plant output is taken, the figure obtained is substantially affected by this preponderance of small communities.—*Ed.*

coolers are also a factor in the arid regions.

Effect of City Size

The size of city appears to be especially important since the per capita use for small communities tends to be less than for large communities, as indicated by Table 3.

Table 2 shows that, of the total number of water supply units, 66 per cent obtain their water from wells; 24 per cent, from streams, lakes or reservoirs; and 10 per cent from springs. For volume of water used, however, the figures for ground water and surface supplies are reversed: 24 per cent of the volume is derived from wells; 74 per cent from streams, lakes or reservoirs; and only 2 per cent from springs. The explanation may be found in the average size of the plants: those with wells as a source have an average output of 0.28 mgd.; those with streams, lakes or reservoirs as a source, 2.8 mgd.; and those with springs, 0.16 mgd.

TABLE 3

Relation of Size of City to Per Capita Use

Population	Avg. Per Capita Use *gpd.*
500	60
1,000	85
5,000	135
10,000	140
50,000	140
100,000	140

The greater volume of surface water used is due almost entirely to the fact that large cities, such as New York, Chicago, Philadelphia and San Francisco, use river and lake water almost exclusively. The smaller communities —greater in number—are likely to find wells and springs more economical of development and operation, and the supplies are sufficient for their needs.

The total production of water by water works in 1945 averaged 12,000 mgd., equivalent to 13,200,000 acre-ft. per year. Although this amount is far less than that consumed for irrigation (40,000,000 acre-ft.), municipal use now represents an important component of water utilization in this country.

The ultimate demand for water in a growing nation like the United States is not yet in sight. Even more liberal use of water in homes and factories in the next generation can be expected, as well as a larger population and, to a lesser degree than heretofore, an extension of public water supply systems to areas not yet served. By making an adequate evaluation of the supplies available in areas of present and potential development, a long step can be taken to meet the demand and avoid shortages.

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Current Developments in Ground Water Law

Panel Discussion

A panel discussion presented on May 31, 1949, at the Annual Conference, Chicago.

C. H. Bechert

Director, Div. of Water Resources, Dept. of Conservation, Indianapolis, Ind.

As in most glaciated states, Indiana has a relative abundance of ground water, sufficient to meet most of its domestic and industrial needs. This statement is not strictly true for areas in the southern part of the state which are unglaciated, but, generally speaking, Indiana has been faced with few critical water supply shortages. In recent years, however, some communities have been finding it increasingly difficult to keep pace with the additional demands for ground water. Not only has the population increased rapidly during the past decade, but new industrial processes are requiring larger and larger quantities of cool water. There is also an increased need of ground water for air-conditioning purposes, and for domestic use in rural areas now served by electricity. Because of these facts, coupled with reports and rumors of a diminishing water supply and the lowering of ground water levels in the state, the public has been made to realize that some action may be necessary to conserve and safeguard this vital resource adequately.

Only in recent years has the public expressed concern over its water resources, and not until 1947 did Indiana attempt to control or regulate the use of ground water by legislative action. Indiana became a state in 1816, but until 1947 common-law rights governed all litigation over the use or diversion of ground water. The eighty-fifth General Assembly, however, sensing an aroused popular sentiment against the practice of wasting water resources, especially for air conditioning, took initial steps to control the use of ground water in the future. A bill was introduced prohibiting the withdrawal of more than 200 gpm. of water from the ground for cooling purposes unless such water was returned to the ground or circulated through cooling towers or other devices and reused, or a permit was obtained from the Indiana Dept. of Conservation to do otherwise. Before the bill was finally passed, it was amended to restrict the withdrawal of more than 200 gpm. of water from the ground for use in air conditioning or cooling of air *only*, and did not apply to the use of ground water for other types of cooling. It was not the intent of the legislature to pass a drastic measure on the subject, but one which would serve primarily as an initial step in focusing the public's attention on the need for future control of the use of ground waters and for water conservation.

The law as passed in 1947 provided no penalty for violation of its provisions nor was any money appropriated for

administering it. For these reasons, and also because of the fact that the law restricted the use of ground water for a specific purpose and hence raised a question of constitutionality, no attempt has been made to enforce it vigorously. It has served its purpose, however, in arousing the public and making it more water conservation conscious.

Proposed Legislation

A bill was introduced in the 1949 legislature which would have repealed the 1947 law and would have placed a control on the future use of ground water not only for air conditioning but also for all other purposes. Under the provisions of this bill, the Indiana Dept. of Conservation would have the authority to determine and describe areas of the state where the withdrawal of ground water exceeds or threatens to exceed the natural replenishment of such waters. The department could designate as critical those areas in which: [1] ground water levels had been on a decline during a prior five-year period; [2] the average quantity of water being removed amounted to 80 per cent or more of the average annual quantity of water being returned to the ground by natural and artificial means; [3] the average annual quantity of water being removed from any individual water-bearing stratum exceeded 85 per cent of the average annual quantity of water being returned to the same stratum; or [4] the water being removed from the ground for purposes other than drinking and sanitation was in such quantities that the health and welfare of the area was being endangered.

In areas pronounced critical by the department, it would be unlawful for "any person, firm, corporation, association or governmental agency, except public water utilities, privately or publicly owned, engaged in supplying water to the residents of any city, town, village or public institutions for ordinary drinking and sanitation purposes, to withdraw or use for any purpose ground water in quantities in excess of 100,000 gpd., in addition to the quantity any such person, firm, corporation, association or governmental agency shall be using at the time the order pronouncing the area as critical becomes effective, unless such person, firm, corporation, association or governmental agency shall first obtain a permit from the Department to withdraw or use a greater quantity."

The bill also placed restrictions on flowing wells with an output over 10,000 gpd. Further, it provided that, in granting a permit, the department could impose such conditions or stipulations as might be necessary to conserve the ground waters of the area and prevent their waste, exhaustion and impairment. The department might also require the user to return water to the ground through wells, pits or spreading as a condition for issuance of a permit. The bill as written provided a penalty of not less than $25 nor more than $500 for any person, firm or corporation violating its provisions.

The above bill was passed by the state senate with one dissenting vote and was reported out favorably by the Natural Resources Committee in the house. Because it was introduced at a late date, there was insufficient time for it to be acted upon by the house and it failed to become law. There was very little opposition to it, however, and many of the senators and representatives with whom the author discussed the bill felt that it was needed and should be enacted.

This bill would be much easier to administer than the present law, since it would apply only to areas declared critical by the department and not to the state as a whole. It would require much less policing, and, as it carries a penalty, it would be much easier to enforce. Water users, well drillers and the general public have reacted favorably to the present law, although, as stated before, it is limited in scope and was not intended to establish a tight control over ground water resources.

Although the data collected during the past several years by the Indiana Dept. of Conservation and the U.S. Geological Survey indicate that ground water levels in the state show no serious decline, with the possible exception of a few areas, it is felt that additional legislation is needed to safeguard the present supplies properly for future generations. It is the considered opinion of the author that either the above bill or an amended version of it will be enacted into law by the General Assembly at its next session and that a law of this type will meet the state's needs for some time, at least until a more accurate appraisal is made of its ground water resources.

George S. Knapp

Chief Engr., Div. of Water Resources, State Board of Agriculture, Topeka, Kan.

IN 1945 the Kansas legislature passed a general act relating to the appropriation of both ground and surface water. The act provides that every person intending to acquire an appropriation right to any of the waters of the state for beneficial purposes, other than domestic use, may do so only by making application to the chief engineer of the Div. of Water Resources for a permit. Applications containing the information specified are given a priority number and thereafter examined. If found defective, inadequate or insufficient, the application is returned for correction but retains its priority of filing.

All applications made in proper form which contemplate the use of water for beneficial purposes will be approved if the proposed use does not conflict with an existing use and does not prejudicially and unreasonably affect the public interest. Upon approval of the application, the applicant is authorized to proceed with the construction of the works and otherwise to perfect the proposed appropriation. When such works have been completed and the water has actually been applied to the proposed beneficial use, as provided in the approval of the application, an examination is made of the project. If it is found that the works have been completed and the appropriation right has been otherwise perfected, a certificate of appropriation is issued. This certificate is intended to grant a continuous right to use the water for a definite beneficial purpose and at a definite location, subject to prior rights. The statute provides that the right of the appropriator to the use of the water shall terminate when he ceases for three years or more to employ it for the beneficial purposes authorized in the certificate.

This legislation was enacted to supersede the English common law (adopted by the first territorial legislature of Kansas in 1855) under which Kansas courts have held that the owner of land may appropriate underground water for any use and in any amount without reference to its effect upon his neighbor's land or supply of water, but that he could not thus destroy or diminish the flow of surface water to the in-

jury of a riparian owner except by condemnation proceedings (*City of Emporia* v. *Soden*, 25 Kan. 588). The state supreme court has also held (*State*, ex rel., v. *Board of Agriculture*, 158 Kan. 603) that an owner of land owns its surface and underground water by the same title as he owns the land itself.

The Appropriation Act of 1945 recognizes the right of any common-law owner by providing that the chief engineer of the Div. of Water Resources shall proceed to gather information essential to the proper determination of vested rights of all parties using water for beneficial purposes other than domestic at the time the act became effective, June 28, 1945.

The change from the common law is intended to be accomplished by providing in the act that: "If any appropriation, or the construction and operation of authorized diversion works results in an injury to any common-law claimant, such person shall be entitled to due compensation in a suitable action at law against the appropriator for damages proved for any property taken. An appropriator who has acquired a valid right under this statute may prevent, by injunction, a subsequent diversion by a common-law claimant of private rights without being required to first condemn possible private rights. An appropriator shall have right to injunction relief to protect his prior right of beneficial use as against use by an appropriator with a later priority of right" (82*a*–716, 1947 Supplement to General Statutes of Kansas, 1935). This provision constitutes, in effect, a form of condemnation of unused or assumed common-law rights of either kind.

A judicial construction of this act has not yet been made; however, there is now before the Kansas supreme court a case to test these provisions as they apply to the appropriation of water from a stream made under a permit from the chief engineer of the Div. of Water Resources.*

Application of Doctrine

The application of the appropriation doctrine to ground water raises a number of questions, among which is whether the rule of priority of right can be applied to ground water as it has been to surface water. It is difficult to do so because the available quantity of ground water does not fluctuate rapidly from day to day as stream flow does. Even if it moves in well defined channels, ground water constitutes essentially a reservoir and not a stream. Its surface is drawn down slowly with use, and the supply is replenished slowly. It is only the earliest appropriators from surface streams who enjoy their full measure of water in all years. The remainder receive their appropriation on a fewer number of days, depending on the relative priority of their appropriations. The last appropriators may be entitled to water only during the few days from time to time when the stream may be almost at flood stage. In applying the appropriative doctrine to ground water, it is necessary to determine the quantity which may be withdrawn each year, and from year to year, without depletion of the reservoir. Those users whose aggregate appropriations fall within this limit become, together, a preferred group which receives a full supply each year, whereas the later, would-be appropriators are denied any part of the water supply. If there is considerable ground water recharge in an area, sub-

* The act has since been held constitutional (*State*, ex rel., v. *Knapp*, 167 Kan. 546).

stantial use can be made of such a reservoir without materially lowering the water table or gradually exhausting the supply. A very different situation exists in portions of the High Plains extending from western Nebraska through Kansas and into the Panhandle of Texas. In western Kansas, in deposits of the Pliocene and Pleistocene age there are saturated sands and gravels, in some places to a thickness of more than 600 ft. The quantity of water in storage is enormous, but in that subhumid area the recharge for practical purposes is almost nil.

The problem of the administration of ground water laws in areas such as these was summed up in 1948 by Carl G. Paulsen, Chief, Water Resources Branch, U.S. Geological Survey, in these words: "Eventually a decision must be reached as to how long the stored water should be made to last and how it should best be developed. The problem is one for the economists, statesmen and philosophers, more so than for the engineers. To make the decisions and to devise and enforce the necessary laws will be an exceedingly difficult problem."

Howard T. Critchlow

Director, Div. of Water Policy & Supply, State Dept. of Conservation and Economic Development, Trenton, N.J.

Under the new state charter, reorganization of the Executive Dept. in New Jersey has resulted in the consolidation of the Dept. of Conservation and the Dept. of Economic Development into the Dept. of Conservation and Economic Development. This agency is divided into five sections, one of which is the Div. of Water Policy and Supply. The latter has control over the public and potable water supplies of the state under laws which were passed in 1907 for surface waters and 1910 for underground waters. The division and its predecessors have rendered 685 decisions under these laws. Decisions are subject to review for reasonableness, legality and form, and several have been brought before the courts, in nearly all cases the decisions being sustained. No part of the statutes has been declared unconstitutional. It is believed that decisions have been fair and equitable and in the public interest.

The general procedure is to allocate the waters on application, after hearing and on proof of [1] public necessity, [2] noninterference with existing water supplies, [3] protection of the supply from contamination by means of proper filtration or treatment and [4] protection of the dry-weather flow of the stream so as not to cause unsanitary conditions; it is also required that the appropriation shall not otherwise cause undue injury to public or private interests.

In 1947 the legislature extended the state's control of ground waters to cover private, domestic and industrial use by enacting Chapter 375, which became effective July 1, 1947. This law gives the Div. of Water Policy and Supply authority to delineate from time to time areas of the state where the diversion of subsurface and percolating waters exceeds or threatens to exceed the natural replenishment of such waters. Under this legislation, two so-called "protected areas" have been established. The first includes certain portions of Middlesex and Monmouth Counties and was established October 6, 1947. The second protected area, including certain portions of Burlington, Camden, Gloucester and Salem Counties, was established on December 1, 1947.

Under this act, thirteen applications have been considered, nine of which were approved, representing diversions from a total of twenty wells with an aggregate approved diversion of 12,300 gpm., or 17.6 mgd.

In the same year Chapter 377 was also enacted, which required parties constructing wells in excess of 100 ft. in depth to obtain a permit from the Div. of Water Policy and Supply. Under this provision, a total of 1,484 applications have been processed, of which 145 (approximately 10 per cent) were for wells diverting 100,000 gpd. or more. This law also provides for the licensing of well drillers.

Additional Legislation

Approximately 30 per cent of the water used for public and potable purposes in New Jersey is obtained from wells. Although the use of wells is not limited to any particular part of the state, most of the public supplies in South Jersey are obtained from underground sources. In connection with its duties, the division and its predecessors have been making investigations of the ground water resources since 1924. About ten years ago the need for additional legislation to control the use of water from private wells was indicated by these studies. It was not until 1947, however, that such a law was passed, as previously mentioned. In certain areas, overdraft was indicated, as well as pollution of some water-bearing sands by the ingress of salt water, particularly in the Pleasantville area back of Atlantic City and the Parlin area at the mouth of South River where it enters the Raritan. The control over private wells now gives the division authority to regulate the taking of water where protected areas have been delineated. The use of water for air conditioning and cooling is making it necessary to require the water so used to be returned to the ground through "recharge" wells. This practice will permit the use of these valuable resources for cooling purposes without permanently diminishing the supply.

Artificial recharge of ground waters is being practiced in many localities in New Jersey, generally through open channels and lagoons excavated in the areas overlying the well field. One large industrial user obtains a dependable supply of 15–20 mgd. from wells located on the shores of a large artificial lake. This company, as well as another large industrial firm, has recently obtained permission to construct additional wells under Chapter 375, Laws of 1947. These grants were made after considerable testimony was taken in hearings. The grants included specific conditions, however, for controlling the situation in the future if operation indicates serious interference with other supplies and the possibility of contamination from surface streams believed to be feeding the intake area.

J. C. Thompson

Exec. Engr., Water Power & Control Commission, State Conservation Dept., Albany, N.Y.

The general control of water supply matters in New York State was first vested in one of the earlier predecessors of the present Water Power and Control Commission about 1905 and has been under the jurisdiction of the present commission since about 1927. Originally the jurisdiction of the commission and its predecessors was concerned only with new and additional sources of public water supply involv-

ing the acquisition of land, but, in about 1911, this jurisdiction was extended to cover all new and additional sources of supply even though the taking of land was not a part of the project. About the same time the commission, which previously had been charged with making determinations only on possible interference between various municipalities engaged in developing or proposing to develop such new supplies, was given further jurisdiction in these matters. At present the commission must make affirmative determinations on each of the following questions before it may approve applications presented to it:

1. Are the plans justified by public necessity?
2. Do they provide for the proper and safe construction of all work in connection with the proposed project?
3. Do they provide for the proper sanitary control of the watershed of the proposed source of supply or for the proper treatment of the water?
4. Are the plans just and equitable to other municipal corporations and civil divisions of the state affected thereby and to the inhabitants thereof, with particular consideration being given to their present and future necessities for sources of water supply?
5. Do the plans provide for the determination and payment of all legal damages, both direct and indirect, which might be caused by their execution?

With regard to the last question, it should be noted that, although the existing statutes provide for the payment of direct damages, no provision is made in the general statutes for the payment of indirect damages should they occur. The commission must determine whether or not such damages are likely to result, and if they may, provision for compensation must be made, by special legislation if necessary.

Upon receipt of an application for approval of a project, the commission conducts a public hearing and thereafter may approve such an application, modify and later approve it, or reject it. An application must be rejected if the commission cannot affirmatively answer any of the above five questions, either with respect to the original plans or to plans revised in an effort to make such determinations possible. Since the first predecessor of the commission originally took jurisdiction over such matters, approximately 2,000 applications have been filed with and acted upon by the commission. Although numerous projects involved the development of surface sources of water supply, a relatively large percentage was also concerned with the development of many types of ground water supplies.

Long Island Conditions

About 1933 it was first generally learned that ground water conditions in the four Long Island, N.Y., counties were quite serious, with static ground water levels 40 ft. or more below sea level in certain areas in the western part of the island, particularly in Kings and Queens Counties (New York City). As the island is surrounded by salt water, there has been a progressive saline intrusion into the wells. Wells are the only sources of public water supply available to most residents on the island, particularly in the easterly counties outside of the city, and, as far as can be determined, the only water which reaches these underlying ground water strata is that which actually falls on the island itself. This serious lowering of the ground water table has

been brought about by almost unlimited and unregulated pumping from the wells in volumes far in excess of normally expected usage. Such water is consumed not only for domestic and sanitary purposes but also for commercial and industrial uses and for air conditioning, the latter rapidly increasing.

To cope with the situation and, if possible, to save the water-bearing beds from absolute destruction, the legislature has enacted new legislation requiring the licensing of all well drillers in the four Long Island counties. The administration of these sections of the law was first handled in the office of the commission in Albany, but later an additional office was established in New York City, and at a still later date this office was removed to Jamaica, Long Island, where it is now located. The Jamaica office of the Commission is now headed by Arthur H. Johnson, whose paper (*see* p. 1010) gives accurate and complete information on the operation and success of this law. It may be noted at this point, however, that the administration of the law has resulted in much improved conditions and in a substantial recovery of the ground water level in the most seriously affected areas.

Except for control over wells used exclusively for public water supply purposes, the provisions of the New York State laws relating to the control and use of wells are restricted in their application to the Long Island counties only and do not apply to any of the remaining 58 counties of the state. It appears that the time is approaching when it may become necessary to extend the application of these provisions to other areas in which critical conditions might occur. With this in mind, the commission is considering the possibility of securing additional legislation to permit it to determine such "critical areas" and to require the application of the Long Island provisions of the law or some similar sections in these areas. At present the commission is cooperating with the U.S. Geological Survey in appropriating funds for studying ground water conditions throughout the entire state. Certain reports on this subject already have been prepared and released, while others are now ready for printing and subsequent distribution.

Priorities

George S. Knapp (*see* p. 1004) refers to the Kansas practice of granting priorities to certain applicants for the use of sources of supply. It is the author's understanding that, to some extent, this procedure is also followed in other states. In New York, however, the trend has been away from such a practice, as it is not desired that any one municipality be permitted to take over rights in any of the state's waters unless such rights are to be exercised immediately without undue effect on other municipalities or civil divisions of the state. Such priorities, when granted, are given only to a limited extent, and approval by the commission is made subject to the requirement that construction work in connection with any proposed project be carried out within a definite period of time—generally not more than three to five years after the date of the decision. Unless the works are completed within that time or the commission sees fit to extend this period, approval expires on the date set, and renewed approval of the development of such a source of supply can then be secured only on further application.

Arthur H. Johnson

Assoc. Engr., Water Power & Control Commission, State Dept. of Conservation, Jamaica, N.Y.

Long Island, N.Y., is an island 1,401 square miles in area lying in the Atlantic Ocean northeast of Manhattan (New York City) and separated from it by the narrow East River. Its inhabitants number more than five million—one-third of the total population of the state and more than 50 per cent of the population of New York City. Only seven states have a greater population. The residents of the island depend on wells for their water supply, except in certain areas at the west end which are supplied by New York City from upstate sources.

In April 1933, Section 521-*a* of Article XI of the Conservation Law was passed by the New York State Legislature, placing the ground water resources of the four Long Island counties under the jurisdiction of the Water Power and Control Commission. Interpretation of the new law by the commission resulted in the policy of prohibiting the drilling of any new well equipped with a pump having a capacity in excess of 69.4 gpm.—equivalent to 100,000 gpd.—unless the water pumped was returned in an uncontaminated condition into the ground through some approved structure, usually referred to as a diffusion well. The law was not retroactive on wells put down prior to April 28, 1933, and wells to be used solely for agricultural purposes were exempted. In 1941 fire wells were also exempted from jurisdiction by the commission.

From January 1936 to January 1949 it is estimated that 72 bil.gal. of water, or an average of 15 mgd., has been returned to the ground through approximately 355 diffusion wells and recharge basins. During the air-conditioning season of about 100 days, it is estimated that 50 mgd. of well water is pumped and diffused on Long Island.

Section 521-*b*, passed by the legislature in July 1935, required the licensing of all persons engaged in the business of well drilling in the four Long Island counties. To date 275 well driller's licenses have been issued. The commission does not advocate the approval of the driller's mechanical ability as a part of requirements to obtain a license. The main purpose of licensing drillers is to control the withdrawal of ground water and to obtain information regarding formations encountered, water levels and test pumping data. Drillers are required to submit a preliminary report before sinking the well and a completion report after finishing it, which includes the log and other pertinent data. Records of approximately 13,000 wells put down on Long Island are now on file in the Jamaica office of the commission and may be inspected by any interested person.

At first the law pertaining to diffusion was looked upon with much disfavor by many of the drillers, but gradually their views changed. At a recent convention of the New York Section, one of the largest drillers operating on Long Island spoke highly in favor of the law.

Well Data Obtained

Under controlled drilling, the commission has been able to compile well data from source records, pertinent to the ground water resources of Long Island. Such data include:

1. Location of wells and complete well and pump records

2. Log of formations
3. Water levels and water-bearing strata
4. Water temperature, salinity and contamination
5. Location of permeable formations
6. Correlation for diffusion analysis
7. Number of operating and non-operating wells
8. Number of metered and observation wells
9. Pumpage statistics
10. Total industrial pumpage diffused and not diffused
11. Quantity of well water diffused for air conditioning or other industrial use.
12. Recharge statistics and water level fluctuations.

In recent years pumpage has decreased and water levels have recovered, as shown by the records of many key observation wells. It is believed that this recovery is in part, if not largely, due to the successful operation of the law.

Ralph J. Bernhagen

Chief Geologist, Div. of Water, Dept. of Natural Resources, Columbus, Ohio.

The status of ground water laws in Ohio can be described rather briefly. The Ohio Water Supply Board was created by the General Assembly in 1941 and became the Ohio Water Resources Board in 1945.* The principal duties of the board are to collect, study and interpret all available data on the waters of the state. The board is primarily a research organization with a minimum of regulatory power.

In 1945 the law was amended to give the board authority to establish rules and regulations for the drilling, operation, maintenance and abandonment of water wells. The main purpose of the rules and regulations is to prescribe means of preventing the contamination of the underground waters of the state.

The following rules and regulations are in effect at the present time.

1. *Defective wells.* In these rules and regulations, the term "defective well" is used to designate any water well drilled, dug or excavated which encounters water containing salt, sulfur or other substances which make such water unpotable, and which is so constructed as to permit the commingling of potable and unpotable waters, or a flowing well which lacks the necessary devices to control the flow of water therefrom.

2. *Acceptable methods for preventing the construction of defective wells.* The construction of defective wells as herewith defined is hereby prohibited:

(a) In constructing a well, if unpotable water is encountered in a stratum that lies *above* a stratum containing potable water, the well shall be cased completely from the surface of the ground to the bottom of the stratum containing the unpotable water, or deeper if necessary, and the casing shall be seated securely and it shall be mudded or cemented if this is necessary in order to make a tight seal and prevent the entrance of the unpotable water into the well or into the potable-water stratum.

(b) In constructing a well, if unpotable water is encountered *below* the potable water stratum, such unpotable water shall be shut off by properly filling the well with heavy mud to a level within a few feet of the bottom of the potable-water stratum, and sealing the well to the bottom of the potable water stratum with Portland cement concrete.

3. *Acceptable methods for repairing defective wells.* Defective wells which are to be continued in use must be repaired as follows:

* Now incorporated in the Div. of Water, Ohio Dept. of Natural Resources.—*Ed.*

(a) In a defective well where the unpotable water lies *above* the potable-water stratum, the well shall be recased either by withdrawing the old casing and replacing it with a new casing of like diameter or else by inserting a new casing of smaller diameter without withdrawing the old casing. The annular space between the two casings shall be sealed with grout.

(b) In a defective well where the unpotable water lies *below* the potable-water stratum such water shall be shut off in a manner prescribed in Rule 2 (b).

4. *Acceptable methods for abandoning wells.* When a well is no longer used it shall be capped by acceptable methods unless the well has become defective, in which case it shall be plugged in a manner as follows: the well shall, if practicable, be cleaned out and then shall be properly filled with heavy clay-laden fluid or concrete.

5. *Acceptable methods for completion of wells.* On completion of the drilling operation, the top of the well shall be adequately secured against contamination at all times. To prevent contamination from the surface, the outside casing shall extend above the surface of the ground to a suitable height so as to prevent the entrance of surface water. Where pump pits are excavated the wall of the pit shall be sealed or cemented and built up to a suitable height so as to prevent the entrance of surface water. Where pump pits are within areas subject to inundation by rivers, the pits shall be constructed so that they may be tightly sealed to prevent contamination by river water.

6. *Flowing wells.* Any flowing well must be furnished with such mechanical appurtenances as will effectively control the flow from such well. Any flowing well from which water is wasted and from which there is no apparent beneficial use is deemed not only a public nuisance but is considered to be in violation of sound conservation practices. Whoever causes or permits waste from flowing wells shall be required to take the necessary steps to prevent such waste in the manner prescribed by the Ohio Water Resources Board.

7. *Use of wells for drainage purposes.* The use of any well for disposal of sewage or other material considered deleterious to the potable underground water is prohibited. In the operation of air-conditioning and cooling systems, water which in the cooling process has become contaminated shall be treated suitably to remove such contamination before being returned to an underground aquifer. Construction of return wells for the purpose of recharging underground aquifers is encouraged, but shall be in accord with techniques recommended by the Ohio Water Resources Board and the sanitary regulations of the Department of Health. If any well is constructed for the purpose of returning water to the ground, the plans must be submitted in advance to the Ohio Water Resources Board and approval given therefor.

Another amendment of 1945 made it mandatory for well drillers to submit the logs of all water wells drilled in the state, except those for farm and domestic purposes. In 1947 the law pertaining to well logs was amended to include all water wells.

At present it is believed that there will be no additional ground water laws introduced for legislative action. In the past there has been some discussion concerning the appropriation of ground water by the state and the regulation of the use of ground water. These proposals have met with a great deal of opposition. In certain areas of the state, ground water shortages exist as a result of overpumpage of the aquifer and undoubtedly a measure of control is needed. If some form of regulation is instituted, however, it will originate through the action of local interests and probably will be enforced by local rather than state authority.

Deep Well Pump Testing

By Frank C. Miramontes

A paper presented on April 29, 1949, at the California Section Meeting, Bakersfield, Calif., by Frank C. Miramontes, Pump Test Supervisor, Pacific Gas & Elec. Co., San Francisco.

THE general theory and use of hydraulic and electrical instruments to test pumping plants have been the subject of many fine articles. The matter is also amply covered in textbooks and in some very excellent bulletins prepared by pump and instrument manufacturers. Hence, this article will be confined to the specific field equipment, methods and practices employed by the Pacific Gas and Electric Co., in testing the pumps of its customers in northern and central California. For the same reasons, formulas will be held to the minimum. Wells, as a separate subject, will be only partly covered.

The pump test service was started in 1923 by what was then the San Joaquin Light and Power Co., now a major division of Pacific Gas and Electric. At present nine two-man crews, strategically located from Bakersfield to Marysville, Calif., are equipped with hydraulic and electrical instruments to conduct field tests, all of which are made at the customer's request in the form of a signed application. A total of more than 70,000 tests have been made to date. Each test involves field measurements and notes, a typewritten report to the customer (with any recommendations needed), and personal delivery or a letter of transmittal. The letter usually contains power usage figures, data on the total amount of water pumped and unit cost figures. As the work is seasonal, during the summer farm irrigation season the crews are usually one or two months behind the test applications. The company conducts free tests because a customer with inefficient pumping equipment will frequently believe that the poor performance of the pump and his increasing power costs are due to improper electric service or excessive rates.

Essentially, the tests yield reasonably accurate, usable information about the pumping plant, which the customer can employ to maintain minimum pumping costs, maximum flow or both. Unless the customer represents a large organization rather than an individual water works operator or farmer, he can usually not obtain this service elsewhere except at considerable cost, if at all. More than 6,000 tests are made each year, and in 1948 approximately 5.2 per cent involved water works pumps. It is the desire of the company to be of maximum service to all classes of customers—agricultural, industrial or water works. As all but a very few of the company's 50,000 agricultural customers have no engineering service available, however, the farmer receives about 87 per cent of the tests made annually.

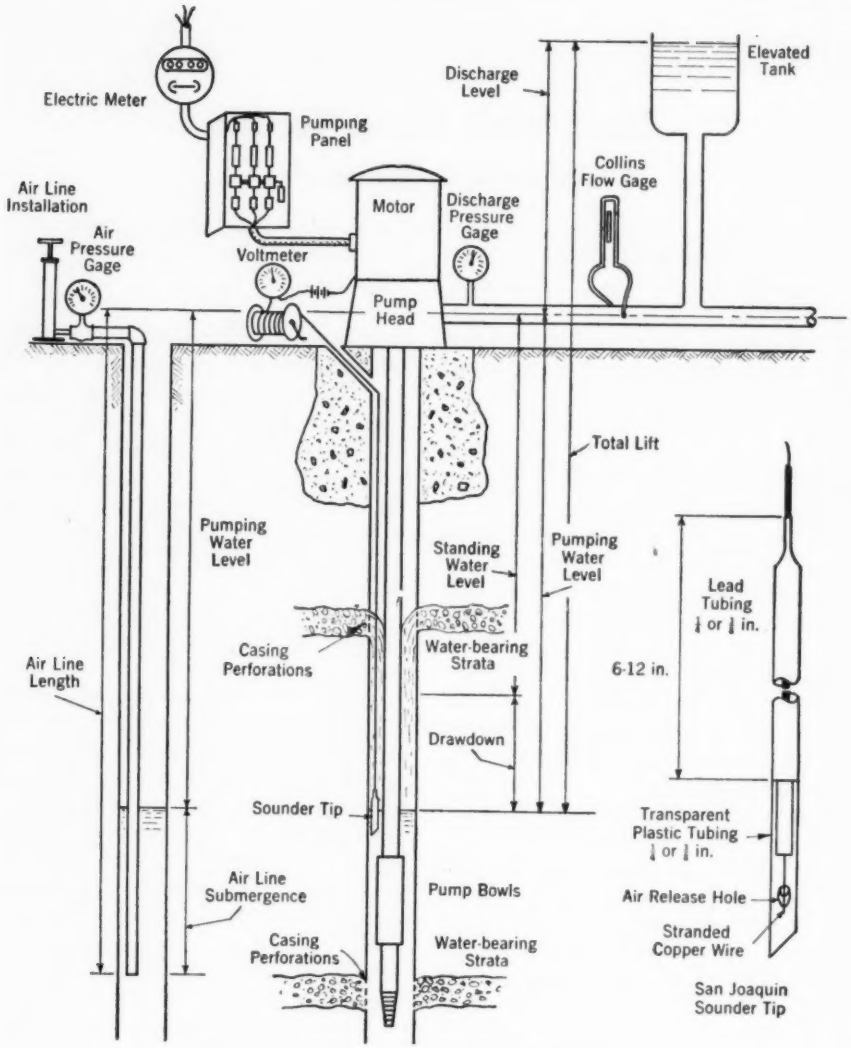

FIG. 1. Test Values for Deep Well Turbine

Testing Procedure

The testing of a deep well turbine in its well requires not only proper instruments but a tester with sufficient knowledge of the characteristics and limitations of these instruments to obtain maximum accuracy when employing them, together with sufficient knowledge of pumps, motors and wells to interpret the data obtained. In order to be of service to the pump owner, the tester does not require instruments of laboratory accuracy. The time and expense involved in installing an orifice, nozzle or weir would seldom

be justified, and, unless a great many conditions of the individual installation were taken into account, these instruments would be no more accurate than the pitot type. Figure 1 shows schematically the test values for a deep well turbine delivering water to an elevated tank in a water system. Most of the terms are self-explanatory. Although the water-bearing stratum (there are often several) above the standing level may provide insufficient water to affect the well water levels materially, the falling water it produces frequently interferes with water level measurements. When the standing water level has been measured, the pump is started. In some areas the pumping level will stabilize in a few minutes, while in others it takes hours. Readings made while the water level is dropping rapidly are generally not simultaneous and also the test is not sufficiently typical of operating conditions to be of much use. When the level has stabilized, further test readings are taken. Assuming the speed to be relatively constant, figures for total lift (pumping level and discharge level), capacity (gallons per minute) and horsepower input to motor are required to determine the overall plant efficiency.

Where the distance to water is very small, the water level can often be seen and measured with a tape line. Usually, however, a sounder tip is connected through a reel of flexible insulated wire to a voltmeter (or milliammeter) and a battery, the latter being grounded to the pump or well casing. The battery voltage is 4.5–45 v. When the sounder tip is lowered until its copper wire touches the water surface, completion of the circuit produces an indication on the voltmeter. The wire is then marked at the reference, usually the centerline of the pump head discharge, and the wire is then raised and measured with a steel or fabric tape. If the tip is lost, a new one is readily connected by a hand splice and taping.

Use of Air Line

Sometimes water falling from an upper perforation gives an unsteady indication on the meter, and the exact point of touching the pumping level cannot be determined. In this situation an air line can be employed. Also there may be so much oil on the surface that the electric circuit cannot be completed. More than 16 ft. of oil (bearing leakage) has been found above the water in wells, although that figure is above average. The lower specific gravity of the column of oil permits it to float on top of the water, giving it an upper surface somewhat higher than, and a lower surface far below, that which would be reached by water alone. A reading taken at the top of the oil would therefore indicate a water level somewhat higher, and at the bottom of the oil much lower, than true hydrostatic pressure would produce. Again an air line can be employed to provide true water levels. Its effective length minus the maximum gage reading (converted to feet) is the water level. Air lines are extremely reliable, provided the effective vertical length is known.

Often the standing water level, but not the pumping water level, can be obtained with an electric sounder. When a permanent air line is in place and a satisfactory standing level measurement with the electric sounder is possible, adding the maximum gage reading in feet to the standing level measurement will provide the effective air line length. Checking is necessitated by the possibility of breakage or leaks. If other means have failed, testers have

sometimes lowered an electric-sounder line—with the sounder tip removed and an open sleeve over the bare wire end—down the inside of the column (which is free of oil) to obtain the standing level and thus determine the effective air line length. Unless handled with great care, for relatively short distances, there is danger of wrapping the sounder line around the tube line or entangling it in a "spider," when such tube line supports are used. A portable air line of rubber hose can be used in the normal well casing space when no permanent air line is available. As the length used can, of course, be measured while out of the well, it is only necessary to raise it 2–3 ft. after a measurement in the well to see if the gage drops an equivalent amount, thus indicating that the line is suspended free and not coiled up at an obstruction. For some hoses, stretch may become important when over 100 ft. of light air line is used. One line of single-ply hose (used to reduce diameter) was found to have a stretch of 19 ft. at 350-ft. suspension. Correction tables which proved fairly accurate were prepared for various lengths suspended and amounts submerged.

The capacity cannot usually be measured with the same degree of accuracy as other values, but the water level sometimes cannot be obtained at all because of insufficient clearance between well casing and pump column, flanged column couplings, a crooked well, mud or debris lodged above the water level, water level below bowls of nearly the same diameter as the well casing, or baffles installed around the column. The drawdown is a measure of the performance of the well rather than the pump.

Discharge head, measured by the discharge gage, is generally used rather than discharge level (the vertical distance from the pump head discharge centerline to the water level of the tank), which credits the pump with friction losses past the discharge gage and also the velocity head. Losses in suction pipe, column and head elbow are rarely credited, due to inacessible gage connection locations when the pump is in a well. Accuracy on levels is limited only by the accuracy of the measuring tape and the pressure gages, the latter being periodically calibrated on a dead-weight tester.

Motor Input

Motor input is measured from the speed of rotation of the meter disc and from the constant applying to that particular meter, multiplied by the constants of the potential and current transformers, if used. Although rules require the electric meters to be accurate only within 2 per cent, the average error will be considerably less than 1 per cent. Motor (and pump) speed is measured with a chronometric speed indicator or revolution counter and stopwatch, either through a hole in the motor cover or with the cover removed. Centrifugal type tachometers are only satisfactory for continuous field use if handled very carefully and frequently calibrated. The voltage and current are measured at the switch box, generally using a split-core volt-ammeter. The voltage between phases is measured to determine if the motor is receiving proper potential, and the voltage to ground is checked to determine if any conductors are accidentally grounded. Current measurements show any possible current unbalance. A small current unbalance is relatively unimportant and may be due to voltage unbalance caused by a single-phase load on the same transformer bank which supplies the motor. Serious

unbalance may mean damaged motor windings or an improper rewinding job and should be investigated further to forestall later burnouts, as well as to reduce energy losses. Calculation of horsepower or kilowatt input from voltage, split-core ammeter readings and estimation of the power factor is only relatively accurate and should be used merely for rough measurements or when the wattage cannot conveniently be directly measured.

Capacity Measurement

Capacity is measured with a pitot type instrument, either the Collins flow gage or the Hall tube described later. With a good piping arrangement, readings approach an accuracy of 3 per cent. Figure 2 shows, at the top, a sectional view of a Collins flow gage in a pipe. It can be moved to measure the velocity at any point across the diameter and during such movement has a constant area in the pipe so that it does not cause changes in velocity distribution. The Collins tube measures velocity by converting the water velocity (V), in feet per second, into head, in feet. One orifice faces upstream and produces a pressure equal to static pressure plus the head due to velocity (h_1). The other orifice faces downstream and produces a pressure equal to static pressure minus the head due to velocity (h_2). In the latter instance, all of the velocity is not converted, hence the constant k_2 used in the following formulas:

$$V = \sqrt{\frac{2g\left(h_1 + \frac{h_2}{k_2}\right)}{2}}$$

$$h_1 = \frac{V^2}{2g}, \qquad h_2 = \frac{V^2}{2g} k_2$$

In Fig. 2, D is the inside pipe diameter and R, the inside pipe radius.

Readings taken with the water manometer connected to this tube do not depend on measurements of static head, but the distance between water levels in the glasses is equal to nearly twice that due to the head produced by one orifice alone. The scale used to read velocity is therefore marked accordingly. The specific gravity of the water does not affect the velocity readings. Obtaining average velocity by multiplying centerline velocity by a constant is an extremely rough method, particularly with the lengths of pipe available at most pumping plants. It has been found that if fairly uniform velocity distribution exists (as shown), the average of velocities measured at two locations $0.707R$ from the center on either side of the pipe center will give results of reasonable accuracy. The tube is reversible, two readings are taken in each position and the average velocity is the average of four readings. This reversal will show up, by unbalance, any orifice stoppage or air pocket. The center velocity, although not used in the calculations, is also measured to give an idea of the shape of the velocity distribution curve and thus to decide whether a two-point, three-area or five-area traverse should be used. For greater accuracy, readings may be taken at three points on each side of center, as shown at Fig. 2 (a), right. These points are in three annular rings of equal area and the points are located, not at the midpoint of the ring, but so that each point separates the ring itself into two equal areas. For greater accuracy, five areas (five points on each side of center) may be used. If required, readings can also be taken at an axis normal to the above points (as indicated by the dots in Fig. 2, right). The axes need not be vertical or horizontal, but at the best angles to survey the velocity distribution of

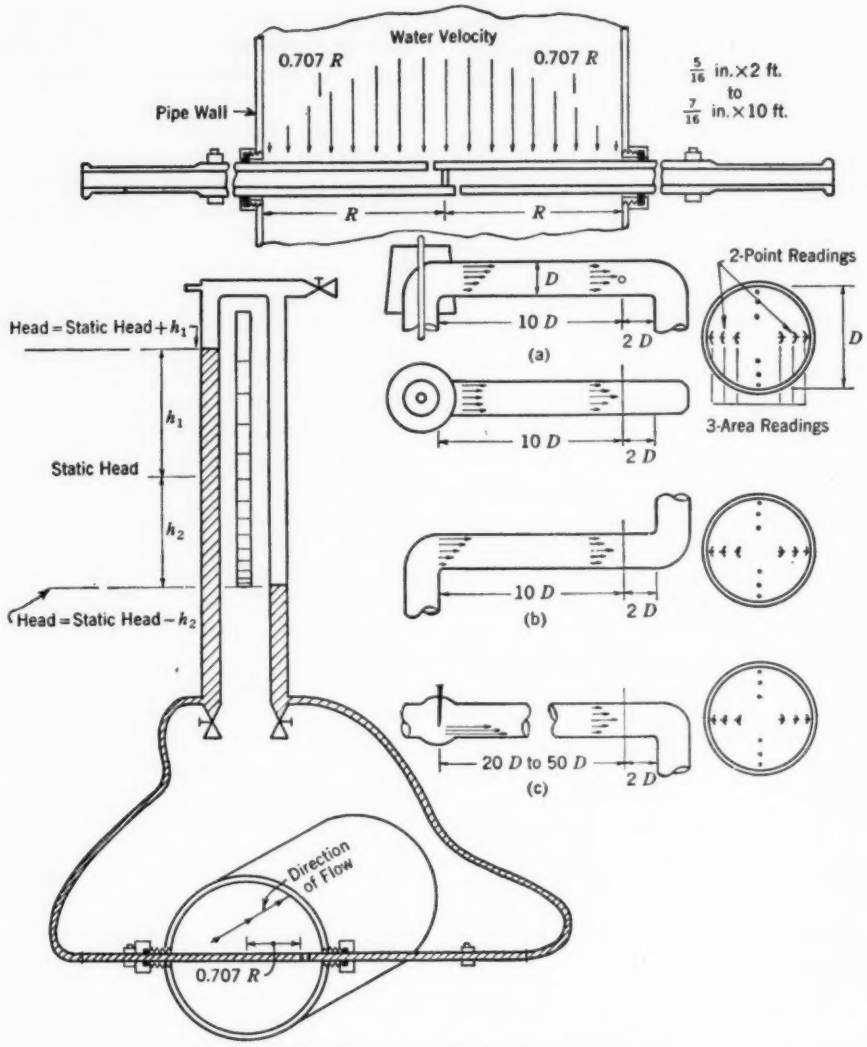

FIG. 2. Collins Flow Gage With Water Manometer

the pipe. For a three-area traverse, the reading points are at distances $0.204D$, $0.354D$ and $0.456D$, on either side of center. Five-area traverse readings are at $0.158D$, $0.274D$, $0.354D$, $0.418D$ and $0.474D$. Distances are given as functions of D because pipe tables and measurements generally list diameter instead of radius. With small pipes, care must be taken to keep the orifice out of the bushing or pipe wall.

The velocity scale is based on $V = \sqrt{2gh}$, but h represents nearly twice the h of an ordinary pitot tube (*see* Fig. 2). Capacity, in gallons per minute, equals k_3 2.45 D^2V. The constant, k_3, is determined by calibration for various pipe sizes and includes the

correction k_2 and the partial effect of the tube area in the particular pipe size manometers are used, and for velocities used. For lower velocities, 3- and 4-ft. above that of the latter, a vertical mercury manometer is employed. Pipe sizes below 3 in. are not desirable. Tubes are in 2-ft. and 3-ft. lengths in the $\frac{5}{16}$-in. size and in lengths up to 10 ft. or more in larger sizes. Depending on the tube diameter used, $\frac{1}{4}$- or $\frac{3}{8}$-in. I.P.S. ("Iron Pipe Size" standard) holes are tapped in the pipe.

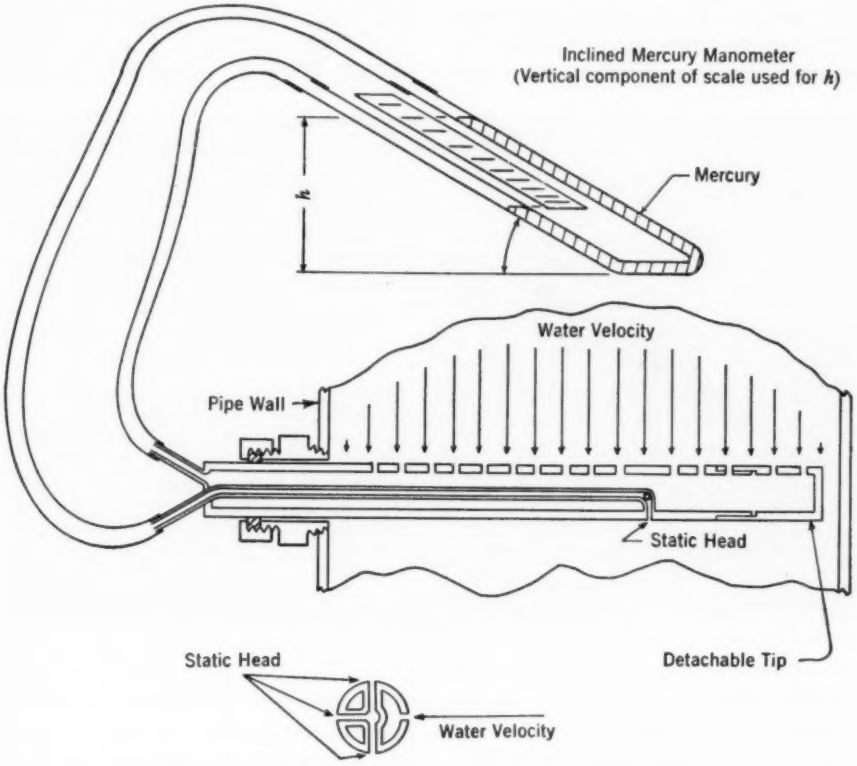

FIG. 3. Hall Tube Connected to Mercury Manometer

Figure 2(a) shows the plan and elevation of a typical pump head and discharge pipe, indicating the effect of the elbow and of the shaft tube on velocity distribution. It is obvious that readings taken in the discharge pipe right next to the pump head will have a greater than normal error, which would be true even if three or five points were used. At 10 diameters past the head and at least 2 diameters ahead of the next obstruction, a two-point or three-area traverse will generally be of ample accuracy. A typical example of unbalanced velocities produced by an elbow is illustrated in Fig. 2 (b). Figure 2 (c) shows why it is so difficult to obtain accurate flow readings past a partly closed valve, such as is sometimes used to limit pump capacity to a reduced well capacity. Although it is *theoretically*

possible to obtain capacity accurately, even when a heavy unbalance of velocity exists, by taking a great number of readings on each diameter and by using a great number of diameters or axes, this method does not work in practice and a more suitable location had better be chosen. A two-point reading, using only a somewhat battered length of pipe temporarily connected to an outlet valve, will provide accuracy superior to a hundred transverse readings at a section with heavy unbalance. This statement is true of all types of pitot tubes, as well as of other instruments.

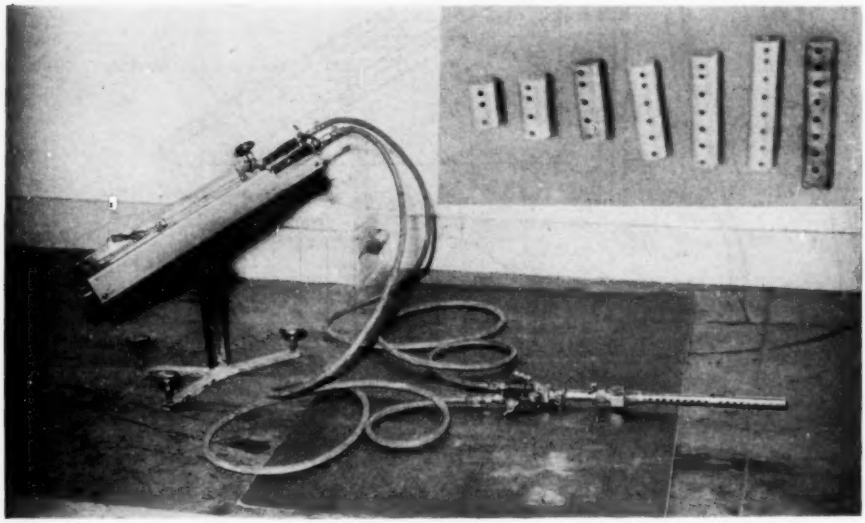

FIG. 4. Hall Tube Assembly

Approximately one-half of the 50,000 agricultural pumps, representing 1,000,000 hp. of connected load on the system, are served by the San Joaquin Power Div. of the company. In this area, the Hall type of pitot tube is used. While the two companies were still separate, San Joaquin adopted the single-reading tube instead of the Collins tube. Actually both instruments in proper hands produce very satisfactory results. Figure 3 shows a rough schematic cross section of a Hall type tube in a pipe and connected to an inclined mercury manometer. The tube shown has detachable tips covering pipe sizes 6–12 in. and, when placed in proper position in the pipe, is not moved from side to side or reversed. Three holes transmit static pressure to one side of the manometer, while a number of holes facing the direction of flow average the heads produced by the velocities which vary from side to side of the pipe. The San Joaquin Power Div. employs a mercury manometer with this instrument, the manometer being inclined, to increase the differential reading. Several small spirit levels are attached to the manometer itself. Each one, when in turn leveled by adjusting screws in the base, provides a separate convenient multiplying factor for the mercury differential on the incline to obtain the vertical component. A water manometer can, of course, also be used

with this tube. Velocity equals $k\sqrt{2gh}$, k referring to the individual calibration of the specific Hall tube used. In practice, a scale proportional to $\sqrt{h}$ is used, and this reading is multiplied by the pipe area, in square inches. Correction for the individual tube and the particular pipe size and capacity is then made by adding or subtracting a value of "gpm." determined by calibration. One ¾-in. I.P.S. hole is required. For both the Hall and Collins instruments it is important that the pipe at the point of velocity measurement be full, carry as little air as possible and be free of mud or other area-reducing deposits or objects.

Figure 4 shows a Hall tube connected to an inclined mercury manometer. Note the shutoff cocks to prevent loss of mercury while connecting up, and the three valves to remove air from the tube. One valve is near each hose bib and one is on the main body of the tube. Also note the adjustable clamp to position the tube. These parts were omitted from Fig. 3 for simplicity and clarity. The adjustable tips are shown at upper right.

A more-or-less standard type of pitot tube and water manometer, used by the San Joaquin Power Div. for pipes over 12 in. in diameter, is shown in Fig. 5. With it, readings can be taken at three, five or more points on either side of center. In other divisions, various lengths of standard Collins tubes are used for this purpose. A standard type of pitot tube is also supplied by Collins for the use of the other crews where it is not convenient to pass the standard Collins tube through both sides of the pipe. As few water works installations in this territory use pipes greater than 12 in. in diameter, these long tubes are employed mostly for reclamation and irrigation projects pumping large volumes of water through relatively small lifts. In this field, pipe sizes of 4 ft. and capacities of 40,000 gpm. are encountered. Current meters have measured capacities of approximately 1,000,000 gpm., representing the discharge of ten low-lift pumps. Separate pump capacities were determined. Measurements of kilowatts, volts and amperes were made for each 2,300-v. motor (225–550 hp.) and water elevation gages were checked

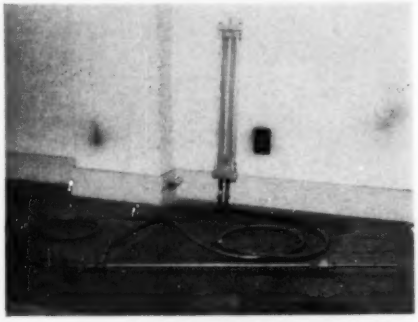

FIG. 5. Pitot Tube Assembly

with a surveyor's level. The company has a hydraulic laboratory at Fresno—designed, built and operated by the San Joaquin Power Div.—where field instruments can be tested against orifices, a weir and volumetric measurement. A motor-driven pump discharges water through selected pipe sizes. E. J. Griffith, Power Engr. of the Fresno office, has given considerable time to the design, construction and operation of this laboratory.

Figure 6 is a photograph of a water works plant being tested, using the Collins flow gage. The test engineer is measuring the water level with an electric sounder. The Collins flow gage is set up for a two-point reading, the reducer at the pump head and the flange (or screw) coupling causing no particular water disurbance, so that accurate

flow measurement is possible. Because the gate and check valves are near the sand trap instead of at the pump head, the tube can be inserted without pressure in the pipe. Figure 7 shows the electric meter, the disc of which is normally timed to measure kilowatt and horsepower input. A load analyzer is also connected to illustrate its possible use when other motors on the same meter cannot be shut down. The instruments, from left to right, measure volts, kilowatts, power factor and amperes.

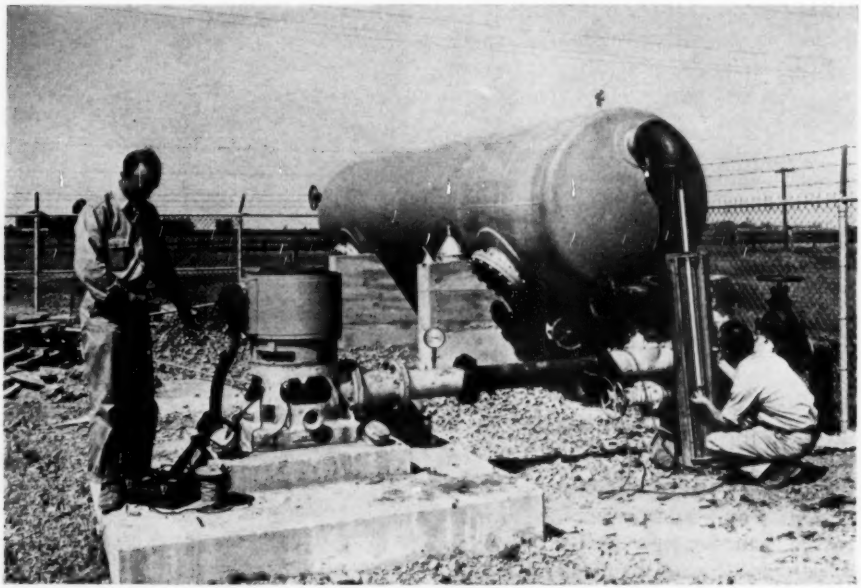

FIG. 6. Testing Water Works Pump

The analyzer is self-contained to 600 v. and 125 amp., in steps, and external potential and current transformers easily extend the range. With flexible leads and test clamp connections, the analyzer can be connected to the circuit by removing from its clip one end of each of two fuses and connecting the leads to the free fuse ends and to their corresponding clips. A potential connection to the other conductor completes the analyzer connections. If the motor cannot be shut down, particularly when the voltage is 240 or less, these leads can be connected above and below the fuses, using rubber gloves, and two fuses can then be pulled out during power readings. Ordinary care prevents short circuits during this operation. The assistant is demonstrating the split-core ammeter on the motor leads at the starter, although the analyzer renders this operation actually unnecessary. The starter has only two thermal relays, the middle conductor being unprotected, a matter which will be discussed later.

Pump Test Reports

The pump test reports emphasize total lift, water pumped and horsepower or kilowatt input to motor to de-

termine overall plant efficiency. These items, with pump speed, are the elements of pump and motor performance. The yield of the well, expressed as "gpm." per foot of drawdown, is a measure of well performance which allows comparison with other wells in the same area or with the same well at other capacities.

Water temperature, in areas where sufficient history is available, gives some indication of which strata supply most of the water. A change in the temperature of a certain well between tests may indicate a loss of supply from one stratum due to well collapse. The use of this information requires considerable knowledge of the specific area. Water temperatures in the company's area of operation vary from 60° to 100°F.

A combined index of pump, motor and well performance is given by kilowatt-hours per 1,000 gal. of water pumped. This ratio is valuable in comparing pumping units on the same system and in estimating power usage for new plants.

When overhauling or new equipment is needed, the customer is urged to consult his pump dealer and well expert for final information, as it is not the function of the pump tester to recommend the particular type, size or manufacture of equipment to be installed or the specific type of overhaul to be performed.

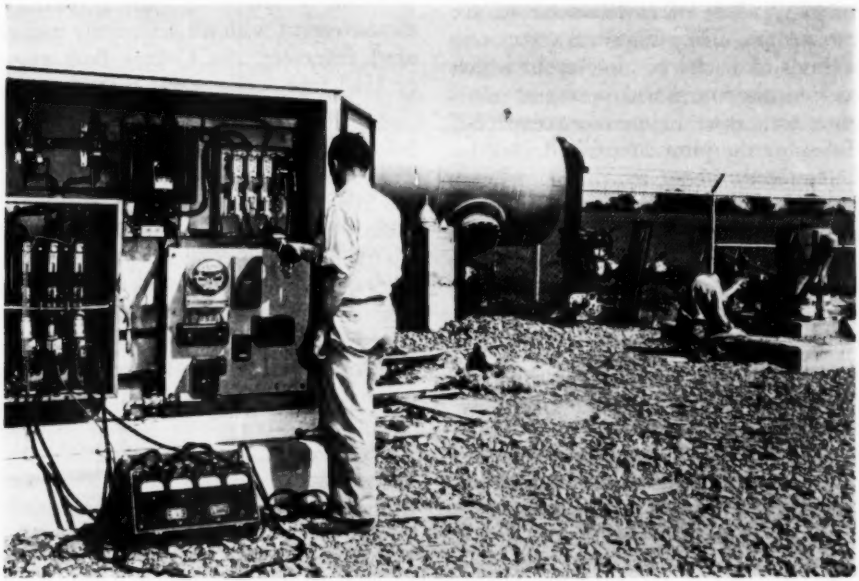

FIG. 7. Electrical Measurements

Special Problems

As motor and pump manufacturers have in general done an excellent job of providing information on the routine care and maintenance of motors and pumps, and as some of the larger water works organizations have engineers and maintenance men of great experi-

ence, only a few brief notes referring to special problems will be discussed.

1. The better the piping arrangement used for testing, the more accurate will be the test results.

2. The ease with which the pitot type of tube can be installed, the water level obtained and horsepower input measured will determine how much testing a crew can do for a customer in one day's time. Under difficult conditions, only two tests may be made per day, while otherwise four to six tests are possible. Figure 8 shows two methods of discharge pipe layout which provide maximum accuracy and minimum test time to measure capacity. Holes for the pitot tube are drilled by the test crew about ten diameters past the pump, leaving two diameters anead of the next fitting. If the pipe is below ground, a permanent pit, extending across it at least 3 ft. on either side (more for pipe above 12-in. diameter), to a depth of 6 in. below the pipe bottom and 3 ft. wide, will allow rapid instrument installation. Where adequate room exists, a head of perhaps 10 or 20 ft. due to water remaining in such a pipe is not prohibitive to installation.

3. Mueller type cocks permanently installed in the pipe render it unnecessary to shut down the pump for tube installation. Such cocks, however, are not particularly desirable for measurements in small pipes as they generally will project into the pipe, causing disturbed flow. In larger pipes, great care should be taken in tapping and in installing the cock, to prevent excessive protrusion into the pipe. Also, where two cocks are used for a Collins flow gage, they must be in alignment.

4. A water meter is of great benefit. It allows a check of capacity at times of the year when the water table may be at an extremely low level and the pump test crew is not immediately available. If several pumps deliver water to a master meter, the addition of individual meters will indicate the failure of one pump. The meter should be installed approximately where the check valve is installed in Fig. 8 (a) or the gate valve in Fig. 8(b), and these two items should be moved two to five diameters farther away from the pump. Meters without calibration for long periods lose their accuracy, however. Often checks can be made simultaneously using primary measurement with an accurately measured reservoir, the Collins flow gage or Hall tube and a water meter.

5. A means of access to the well casing should be provided either in the pump head base or directly under it, or, better yet, by means of a capped pipe, as in Fig. 8(b). The pipe should be welded to the well casing or otherwise securely fastened and sharp edges smoothed. Public health agencies prefer a capped pipe to an open hole in the pump base.

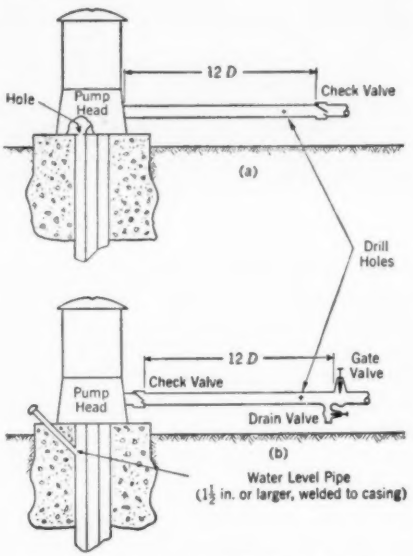

FIG. 8. Preferred Installation Methods

6. Where previous difficulty has been encountered in obtaining the water level, because of insufficient clearance, falling water or excessive oil on the water surface, a permanent air line should be installed and its effective length plainly marked in the pumphouse. Water conditions will dictate whether steel or copper is used. With copper, if compression joints are used, they should also be soldered; otherwise vibration may produce leaks, rendering the air line useless. The customer may desire to have a direct-reading gage and hand pump permanently connected for his own readings, but the test crew will use their own calibrated gage. The air line should be securely fastened so that the attachment of a gage will not cause the line to drop down the well, and it should be sufficiently clear of the pump head to allow turning the gage for connection. If water level and discharge pressure records are kept during the summer low period, the same total-head condition can be duplicated in the winter—when more time is usually available for testing—provided that the discharge pressure can be raised by the use of a valve, or lowered by the use of a large drain valve, as required.

7. Information on the diameter and depth of each size of well casing (if more than one is used), the pump setting, bowl length, length of suction pipe and existence or absence of a strainer should be available in the pumphouse for the benefit of the tester in obtaining water levels and properly interpreting them. A well log, with the location of casing perforations, is of considerable use when reliably prepared.

8. Fuses should be of the proper size and should make good contact with the jaws. The overload relay mechanism should be inspected periodically for free movement which might be hindered by mud daubers and mechanical damage. Thermal relay heaters should be installed only in the size proper for the motor rating and the air temperature where the motor is located. Motors under average temperature and air circulation conditions can generally be safely overloaded 15 per cent, but when in pits or other confined places, even the full rated load may be too much for motor safety.

9. A situation exists with regard to motor protection which is not universally understood and which will, therefore, be very briefly covered here. Two heater elements in the starter will protect a three-phase motor against practically all fault or overload conditions of excessive current occurring on the motor, or secondary, side of the power transformers. Under certain conditions, applying to transformer connections used in many parts of the country, the loss of one primary conductor (due to accidental breakage) will produce a current from two to three times normal in one motor conductor and perhaps only slightly more than normal current in the other two conductors. If this heavy current occurs in the unprotected conductor, and, as often happens, the motor does not stall and the current in each of the other two conductors is not enough to trip the starter, the motor is not protected. If the motor has already been carrying full load, it will probably burn out in 20–60 minutes; otherwise, a somewhat longer duration of the primary outage might be required for a burnout. Each year a large number of motor burnouts are encountered by the company for this reason. It is not practical, from the standpoint of the best all-around service and lowest rates to the customer, for the company to attempt to provide protection against loss

of a primary wire on the primary, high-voltage side. The loss of one water works motor could be very critical during the summer heavy-load period, not to mention the expense of rewinding the motor. A thermal relay should be provided in the unprotected conductor. Thermal type fuses in the switch box will perform the same function, but it would be ideal to use three thermal relays and three thermal fuses. Electrical dealers can recommend the proper sizes of each.

10. Often a customer installs a new pump or new set of bowls with guaranteed performance values and requests the company to make a test to determine if the guarantee has been met. The company is ready to do so, but the tester will not advise the customer to accept or reject the pump as a result of the test. Also, when comparing test and guaranteed values, instrument accuracy limits must be considered.

Summary

1. Pump testing assists the customer in obtaining maximum capacity at maximum efficiency with minimum energy usage and minimum motor size.

2. Both Collins flow gage and Hall tubes, in proper hands, give satisfactory accuracy.

3. Although ten diameters after and two diameters ahead of elbows or other flow disturbers are desirable, satisfactory results can be obtained with half and sometimes one-third of these distances when care in positioning the instrument is exercised.

4. When water works customers are installing new plants or revamping old ones, it is an excellent time to rearrange piping for ease of capacity measurement. When the pump is out of the well, it is a simple matter to provide an entrance to the casing (if not already there) to allow water levels to be obtained.

5. A water meter properly located and periodically calibrated is of great assistance in taking measurements of capacity during the year and shows up decreased capacity due to wear or lowering of the water table.

6. Where experience shows that water levels cannot be easily obtained by the electric sounder, a permanent air line, properly measured and secured, should be supplied.

7. Information on well casing sizes and depths, pump dimensions in the well and effective air line lengths should be available near the pump.

8. All three-phase motors driving such important equipment as water works pumps should have three-element protection.

9. The Pacific Gas and Electric Co. is not always able, with existing test personnel and equipment, to test all plants as requested, particularly during the summer irrigation season. Most farms cannot provide a place to receive pumped water during the winter without damage resulting, while most water works can easily find space in their storage to allow pumping during the winter for an hour or so. Hence, it is preferable to test water works pumps during the winter, acceptance tests being an exception. Some larger water utilities may prefer to do part of their own testing.

10. Pump testing has resulted in higher average overall plant efficiency and has reduced power costs. Analysis of tests made for the company's farm, water works and other customers, and comparisons of their power accounts, show that thousands of dollars are saved each year as a result of the pump testing service.

Effectiveness of Silver Ions Against Cysts of *Endamoeba histolytica*

By Walter L. Newton and Myrna F. Jones

A contribution to the Journal by Walter L. Newton S.A. Sanitarian (R.) U.S.P.H.S., and Myrna F. Jones, Medical Parasitologist, both of Laboratory of Tropical Diseases, Microbiological Institute, National Institutes of Health, Bethesda, Md.

IT has long been known that traces of silver are toxic for bacteria, and for some years it has been recognized that the toxic effect is due to the silver ion. This knowledge has led to numerous investigations of the use of silver ions in the disinfection of drinking water supplies. Although the concentration and exposure period reported as bactericidal vary considerably, in general the concentration has been of a rather low magnitude. To cite a few of the studies: Myers and Mauer (1), using electrolytically produced silver ions as well as various silver compounds, found that 0.10–0.15 ppm. of silver ions was sufficient to destroy *Escherichia coli* within 2½ hours. Castell *et al.* (2), using electrolytically produced silver in tap water, destroyed *Esch. coli* by one hour of current flow of less than 1 ma. with 6 v. They also obtained complete bacterial destruction within ten minutes using silver nitrate in distilled water at silver ion concentrations as low as 0.1 ppm. Harrison (3), in a discussion of tea estate water supplies, declares that, with a reasonably clear water, a drip feed of silver nitrate into the supply before storage would ensure sterilization. The concentration of silver ions indicated was approximately 0.1 ppm. Harrison also states that sterilization can be effected by silver electrolysis; with the particular water under consideration, and with 110 v. (direct current), 10 ma. for one hour would sterilize 1,000 gal. of water. Hoffman (4), who investigated the efficacy of silver as silver nitrate and as catadyn silver under a variety of conditions, states that concentrations of 0.35–0.4 ppm. silver for at least one hour are required for safe disinfection of water. With spore-forming bacteria, he noted no destruction, only "inactivation," with silver concentrations as high as 20 ppm. According to Brandes (5), 0.05 ppm. of electrolytically produced silver will sterilize clear drinking water within an hour. Just and Szniolis (6), using silver salts and electrocatadynization, concluded that 0.1 ppm. silver for drinking water gave generally good results within three to four hours after application.

The results described above prompted a consideration of the efficacy of silver ions for the destruction of cysts of *Endamoeba histolytica*. Harrison (3) suggests that silver is not effective against the cysts, and Fair (7), in discussing wartime research in emergency water disinfection, lists salts of silver among the agents eliminated

from intensive investigation because they were not sufficiently cysticidal. Neither author provides data, however, and no other references to this subject have been encountered. Consequently, experiments were set up to furnish additional information on the cysticidal efficacy of silver ions.

In the present study, attention was devoted at first to the effects of silver ions produced by an electrolytic process, inasmuch as this process has had more application in water sterilization than has the use of salts which yield silver ions. Later experiments, however, were conducted entirely with solutions of silver nitrate in distilled water because they provided better conditions for evaluating silver concentration.

Materials and Methods

Cysts of the NRS strain of *E. histolytica*, obtained from culture, were washed and concentrated by centrifugation in distilled water and were stored at 5°C. The cysts were used one day after preparation in all experiments except one in which they were used on the fifth day. Numbers of cysts were estimated by counting, on a ruled slide, several 0.05-ml. samples of appropriate dilutions made up in distilled water.

In a series of experiments in which the silver ions were obtained by the electrolytic method, the procedure was as follows: Opposite sides of a glass museum jar were covered with silver foil, resulting in two electrodes, each approximately 12 sq.in. in area. The distance separating the electrodes was approximately 2½ in. The source of current was four 1.5-v. dry-cell batteries connected in series. A voltmeter and a milliammeter were connected in the circuit. The leads to the silver electrodes were connected by means of copper clips which remained above the water level at all times. The addition of 560 ml. of standing tap water to the jar as the test medium resulted in a current flow of 6–7 ma. at 6.2 v. In four experiments, cysts were added immediately before the current was turned on, remaining in the water during one hour of current flow. In a fifth experiment, cysts were not added until after one hour of current flow through the uninoculated water; the cysts then remained in the electrolyzed water for one hour, during which no current was flowing. In some experiments, determinations of silver ion concentration by means of a dithizone method (8) were performed on the supernatant fluid obtained by centrifuging the one-hour cyst sample. The supernatant fluid was used because most of the soluble silver it contained would be in the form of silver ions, with the possible exception of silver complexes.

In the series of experiments in which the source of silver ions was silver nitrate, stock solutions of the latter in distilled water were made up at frequent intervals from cp. quality salt weighed out on an analytical balance. Fresh solutions were prepared for each experiment by diluting samples of the stock solution up to 500 ml. in distilled water in concentrations of 1.0–1,000.0 ppm. of silver nitrate (0.635–635 ppm. silver). Sufficient cyst suspension was added to 250 ml. of test medium to provide 250–300 cysts per milliliter in most tests; in some of the earlier tests, a cyst concentration of only 100 per milliliter was employed. In some experiments, silver determinations by the dithizone method were performed on the test medium before the addition

of the cysts, as well as on the supernatant fluid obtained from the first centrifugation of the two-hour cyst sample. This procedure was followed in order to obtain an idea of the proportion of applied silver still remaining as silver ions after a two-hour contact with the cyst material.

In all the experiments, the temperature was 24° to 26°C. Determinations of pH were made by a Beckman pH meter. The criterion of viability of the cysts was their ability to establish growth in modified Boeck-Drbohlav's culture medium (egg slant overlaid with a modified Locke's solution and rice flour).

In both series of experiments, the method of cyst recovery was the same. After the desired period of exposure, a 50-ml. sample was removed and centrifuged. The resulting supernatant fluid was removed by suction and either discarded or used for silver determinations. The sediment, containing the cysts, was washed twice by centrifugation in distilled water to remove the silver remaining in solution. The cysts were then counted, and samples were inoculated into fifteen tubes of culture medium to which the NRS bacterial flora had been added. Five of the tubes were inoculated with an estimated 1,000 cysts each, five with an estimated 100 cysts per tube and the remaining five with an estimated 10 cysts per tube. In those experiments with silver nitrate in which the cyst concentration in the test medium was only 100 per milliliter, cyst recovery from the 50-ml. sample was too low to allow the inoculation of the 1,000-cyst group. The culture tubes were incubated at 37°C. and were examined after three days. If no trophozoites were found, subcultures were made and both the originals and subcultures were examined three days later.

For controls, untreated cysts were allowed to remain at the same temperature for the maximum exposure period used in a given experiment. They were then inoculated into fifteen tubes of culture medium in five-tube groups, containing estimated averages of 20, 10 and 5 cysts per tube. In the experimental series with electrolytically produced silver ions, five additional controls to which a silver precipitate was added were inoculated with 10 cysts each. This was done because of the marked amount of precipitate which resulted after centrifugation of the treated cysts in these experiments and which was inoculated into the culture medium along with the cysts. In order to determine whether this precipitate would interfere with growth, similar amounts of the substance were added to these five additional controls.

Results and Discussion

To provide a basis for the discussion of the results obtained with treated cysts, the controls will be considered first. Growth results for the untreated control cysts for all experiments are presented in Table 1. It can be noted that when an average of 20 cysts was inoculated into five culture tubes, five positive cultures were obtained in every instance but two; when 10 cysts were used, five positive cultures generally resulted. The average number of positive cultures obtained per group of five tubes inoculated with averages of 20, 10 and 5 cysts per tube was 4.9, 4.7 and 4.0, respectively.

It was assumed, therefore, that, with treated cysts, the failure to obtain five positive cultures from the inoculation of five tubes would usually indicate that

TABLE 1

Growth of Untreated Control Cysts

Experiment No.	No. of Cysts Inoculated per Tube			
	20	10	5	10*
	No. of Tubes Positive per 5 Inoculated			
1	5	5	5	5
2	5	4	4	5
3	5	5	4	4
4	5	4	5	5
5	5	4	5	4
6	5	5	5	
7	5	4	4	
8	5	5	5	
9	4	5	4	
10	5	3	5	
11	5	5	4	
12	5	5	3	
13	5	5	3	
14	5	5	4	
15	5	5	2	
16	5	5	5	
17	5	4	4	
18	5	4	4	
19	5	4		
20	5	5	2	
21	4	5	5	
22	5	5	4	
23	5	5	5	
24	5	5	3	
25	5	5	4	
26	5	5	3	
Total positives	128	121	101	23
Total inoculated	130	130	125	25
Avg. positive per 5 inoculations	4.9	4.7	4.0	4.6

* Experiments 1 to 5 were with the silver electrolysis process, which resulted in a precipitate. These additional controls contained some of the same precipitate.

less than 10 viable cysts had been inoculated per tube. An estimate of the amount of destruction could then be made on the basis of the number of cysts inoculated. For example, all positive results with the fifteen tubes would indicate no measurable cyst destruction. Less than five positive cultures with 100 cysts per culture would indicate more than 90 per cent destruction, and less than five positive with 1,000 cysts would indicate more than 99 per cent distruction. No growth with 1,000 cysts was considered as indicative of complete destruction.

Table 2 gives the results obtained with cysts which had been exposed to electrolytically produced silver ions in tap water. In Experiment 2, the cysts were kept for one hour in water through which current had previously passed for one hour. No current was flowing during the exposure of the cysts in this experiment. In the other four experiments, the cysts were in the water during one hour of current flow. The growth results at each sampling are represented as a set of three digits. The first digit indicates the number of positive cultures obtained from five tubes, each inoculated with 1,000 treated cysts; the second digit, the number of positives obtained from five tubes inoculated with 100 cysts; and the third, the number of positives obtained from five tubes inoculated with 10 cysts.

It can be noted from Table 2 that cyst destruction was complete or greater than 99 per cent after one hour of electrolysis. In the three experiments in which observations were made for shorter periods, cyst destruction of more than 90 per cent was evident in some tests. The results with experiment 2 suggest that the silver remaining after the current had been turned off was as effective as silver under the influence of the current.

In general, attempts to evaluate the effectiveness of silver ions as a cysticidal agent by the electrolytic method were not satisfactory. The presence

of various silver ions in the tap water and the increase in alkalinity (up to pH 9.8) during electrolysis resulted in the conversion of some of the silver to white—and, eventually, black-purple—precipitates. In the concentration and inoculation of the treated cysts in the culture medium, a considerable quantity of the precipitate was carried along. Although comparable quantities of this precipitate apparently did not interfere with the growth of control cysts (*see* Table 1, Column 5), it was felt that a fair medium for the growth of the treated cysts had not been provided. Furthermore, the occurrence of the precipitate along with free silver ions precluded an accurate determination of the amount or the nature of the silver that was effective in destroying the cysts. In the three experiments in which silver determinations were performed, the values obtained (17.3–33.0 ppm.) represent only the concentration of silver remaining in solution after one hour of current flow. Presumably, the greater portion of this silver could be considered ionized.

Although these experiments indicated that silver ions produced electrolytically from silver electrodes can destroy cysts of *E. histolytica*, the concentration of silver ion and length of exposure period required were not ascertainable. Consequently, a series of experiments was performed with silver nitrate as the source of silver ions.

In Table 3 are presented the results obtained after the exposure of cysts to various concentrations of silver ions from silver nitrate for various time intervals. As in Table 2, these results are expressed in groups of three digits. In Experiments 22 to 26, the number of cysts recovered after centrifugation permitted the inoculation of only the 100-cyst and 10-cyst groups.

It will be seen from Table 3 that the results were somewhat erratic; varying amounts of cyst destruction occurred in different experiments with the same applied silver and exposure period. For example, in tests with 0.635 ppm. applied silver, Experiment 11 indicated no measurable cyst

TABLE 2

Growth of Cysts After Exposure to Electrolytically Produced Silver Ions

Experiment No.	Final pH	Exposure Period—*minutes*			Silver in Solution (at 60 min.) *ppm.*
		10	30	60	
		No. Positive*			
1	8.9			0–0–0	
2	9.0			0–0–0†	
3	9.7	5–5–4	5–4–0	1–0–0	20.0
4	9.8	5–5–2	5–5–0	3–1–0	33.0
5	9.6	5–3–0	1–0–0	0–0–0	17.3

* Each set of three digits represents the number of positive cultures obtained from 15 tubes, 5 of which were inoculated with 1,000 treated cysts per tube, 5 with 100 cysts per tube and 5 with 10 cysts per tube, respectively.
† In this experiment, the water was electrolyzed for one hour prior to addition of cysts. There was no current flow during the hour that the cysts were in the water.

TABLE 3

Growth of Cysts After Exposure to Silver Nitrate

Expt. No.	pH	Calculated Applied Silver *ppm.*	Exposure Period—*hours*							Dithizone Silver *ppm.*	
			½	1	2	3	4	6	22	Applied	2-hr. Residual
			No. Positive*								
6	6.9	0.635		5–5–1							
7	6.7	0.635		5–1–0							
8	6.4	0.635		5–3–0	1–1–0	1–0–0					
9	6.8	0.635		5–5–3	5–5–1						
10	6.7	0.635		5–5–2	5–4–3	5–3–0					
11		0.635		5–5–5	5–5–5	5–5–3				0.53	0.22
12	6.1	0.635		5–5–3	5–5–3	5–5–2			0–0–0	0.56	0.27
13	6.3	0.635							0–0–0		
14	6.2	0.635			5–1–1		1–0–0	1–0–0		0.54	0.15
15	5.9	0.635			5–4–3		5–0–0	2–0–0		0.53	0.28
6†	6.8	6.35		2–0–0							
7†	6.8	6.35		4–1–0							
16	6.1	6.35		4–3–0	2–0–0					4.6	3.2
17	6.0	6.35		5–5–2	5–1–0	3–1–0				4.7	3.6
18	6.3	6.35		5–5–3	5–3–0	2–1–0				4.4	3.3
19	5.9	31.7	5–4–1	4–1–1	0–0–0					27.	16.
20	5.9	31.7	5–4–0	1–0–0	0–0–0					28.	22.
21	6.0	31.7	5–5–1	3–1–0	2–0–0					30.	27.
22	6.5	63.5	–5–0								
23	6.3	63.5	–0–0								
24	6.7	63.5	–3–1								
25	6.2	63.5	–0–0								
26	5.7	63.5	–0–0								
22†	6.5	317.	–0–0								
22†	6.5	635.	–0–0								

* Each set of three digits represents the number of positive cultures obtained from 15 tubes, 5 of which were inoculated with 1,000 treated cysts per tube, 5 with 100 cysts per tube and 5 with 10 cysts per tube, respectively.
† In Experiments 6, 7 and 22, the exposure period was constant and the concentration of applied silver was varied.

destruction after one hour of exposure; whereas, in Experiment 7, the results indicate a cyst destruction of more than 90 per cent. In most of the experiments with this concentration of silver, however, cyst destruction was not very marked after a one-hour exposure. Variation in results and a lack of marked cyst destruction were also observed after exposures of two and three hours to 0.635 ppm. silver. In the two experiments with four- and six-hour exposure periods, destruction in excess of 99 per cent was the most prevalent finding. In two tests, no growth was obtained after 22 hours of exposure.

In five experiments with an applied silver concentration of 6.35 ppm., vari-

able results were also obtained. Cyst destruction within the first two hours, however, appeared to be greater than it was in the tests with 0.635 ppm. In the two experiments continued for as long as three hours, cyst destruction was estimated to be greater than 99 per cent.

In three tests with an applied concentration of 31.7 ppm. silver, there was evidence of some cyst destruction at ten minutes, with destruction estimated at more than 99 per cent by one hour. Two of the experiments resulted in complete cyst destruction by two hours.

In five experiments with approximately 63.5 ppm. silver, exposures were of ten minutes' duration. Again the results were variable, although there was evidence of cyst destruction in all tests. It can be estimated that, in four of the five tests, cyst destruction was probably greater than 90 per cent.

In single tests with concentrations of 317 and 635 ppm. silver for ten minutes, no growth was obtained with the inoculation of either 100 or 10 treated cysts.

As Table 3 shows, the concentrations of applied silver determined by the dithizone method were invariably lower than the amount calculated to be present on the basis of the dilution of stock solutions. The recovery varied from 70 per cent in Experiment 18 to 95 per cent in Experiment 21, although it was usually greater than 80 per cent. This discrepancy suggests that the two-hour residual figures may be lower than the amounts actually present. These figures suffice to show, however, that a variable but large proportion of the applied silver still remained as silver ions after a two-hour contact with the cyst material, even when low concentrations were applied. The variation in the two-hour silver drop might presumably be associated with the variation in the amount of extraneous material accompanying the cysts, and with the concentration of applied silver.

The differences in pH were not very marked. The variation that did occur (5.7–6.9) did not appear to be correlated with differences in cyst destruction.

These experiments with silver nitrate indicate that cysts of *E. histolytica* can be destroyed by silver ions. In the sterilization of drinking water, however, concentrations of less than 1 ppm. would require much longer exposure periods, and an exposure period of only one hour would require much higher concentrations of silver for cyst destruction than has been recommended for the destruction of bacteria.

Summary and Conclusions

Cysts of the NRS strain of *E. histolytica* were exposed to various concentrations of silver ions for varying time intervals at temperatures of 24°–26°C. The silver ions were obtained from two sources: [1] silver foil electrodes in tap water, using a current flow of 6–7 ma. at 6.2 v. for one hour; and [2] solutions of silver nitrate in distilled water. The criterion of viability of exposed cysts was their ability to establish growth in modified Boeck-Drbohlav's culture medium.

In five experiments, either complete or more than 99 per cent cyst destruction was obtained after exposure for one hour to silver ions produced electrolytically. In four of these experiments, the cysts were present in the water during the current flow; in the other, the cysts were added after the current was turned off. An increase in pH, and the presence of other ions

in the tap water, resulted in silver precipitates which precluded an accurate estimate of the form and concentration of silver effective in destroying the cysts. Dithizone tests, however, indicated that the concentration of silver in solution after one hour of electrolysis was of the order of 20–30 ppm.

The following results were obtained in 21 experiments with cysts exposed to solutions of silver nitrate in distilled water: With approximately 0.63 ppm. applied silver, there was evidence of little cyst destruction at one to three hours in most tests; 90 to more than 99 per cent cyst destruction was obtained at four to six hours; and complete destruction occurred in two tests at 22 hours. With approximately 6.3 ppm. silver, marked cyst destruction occurred in some of the tests after one and two hours of exposure; cyst destruction was estimated at greater than 99 per cent at three hours. With approximately 31.7 ppm. silver, there was evidence of some cyst destruction at ten minutes, and more than 99 per cent at one hour; at two hours destruction was more than 99 per cent in one test and complete in two others. In tests with higher concentrations of silver and an exposure period of only ten minutes, cyst destruction of more than 90 per cent was obtained in four of five tests with 63 ppm., and in single tests with 317 and 635 ppm. silver.

The pH variation from 5.7 to 6.9 did not appear to influence cyst destruction. Dithizone tests for silver indicated that a variable but large proportion of the applied silver remained as silver ions after a two-hour contact with the cyst material.

It is concluded that cysts of E. histolytica can be destroyed by silver ions. It would appear, however, that the concentrations and exposure periods required are considerably in excess of those usually suggested for the treatment of drinking water supplies.

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Experimental Studies of Odor Control at Whiting, Indiana

By Leo Besozzi and J. C. Vaughn

A paper presented on May 30, 1949, at the Annual Conference, Chicago, by Leo Besozzi, Cons. Engr., Hammond, Ind., and J. C. Vaughn, Filtration Engr., Water Purif. Div., Bureau of Eng., Dept. of Public Works, Chicago.

EDITOR'S NOTE: *The quality of the water along the Indiana shoreline at the southern end of Lake Michigan has been the subject of many studies. When engineers were first employed by the Indiana State Board of Health about 1905, one of the earliest studies made related to the extent of pollution of the southern end of Lake Michigan. The Indiana shoreline from Gary west to the border of Illinois is lined with huge industrial plants which draw large quantities of water from the lake for process operations and which return much, if not all, of this water to the lake without treatment. Whiting, Ind., is the site of large oil refinery operations and the industrial pollution of the water in the lake at Whiting is of greater intensity than at any other point.*

It is also necessary to understand that at the southernmost end of Lake Michigan there is no flow of water along a generally definite course, such as is found at Detroit, Buffalo, Cleveland and Toronto. Diversion of treated municipal sewage through purification plants into the Calumet River and thence down the Chicago Drainage Canal serves to lessen the lake pollution. But there still remains some flow of untreated municipal sewage into the lake and there is still a very substantial load of industrial waste in the lake water at points along the Indiana shore. The account which follows is a competent and professional record of special investigations made by the authors in 1947 in an effort to provide Whiting citizens with a public water supply which would meet generally accepted criteria of taste and odor intensity. No question of conformance to bacteriological requirements was involved.

Although the authors' recommendation that ozonation be discontinued was followed for a time, ozone is presently being used in the treatment of the Whiting water supply. It is understood that the municipal sewage load from Whiting upon its own raw water is being reduced through the installation of treatment and diversion works. The oil refineries are reported to be making efforts to reduce their contribution to the pollution of the lake.

TO those who have lived along the south shore of Lake Michigan, the past fifteen years represent a period during which a great improvement has taken place in the quality of the drinking water supply. Until 1934 much of the water being supplied to the area by municipal water works was virtually undrinkable because of tastes and odors. Bottled-water companies were operating on a large scale and were distributing, at handsome prices, most of the water used for human consumption. At the most southerly tip of Lake Michigan, there were but two cities operating water treatment plants—Whiting

and East Chicago, Ind. The nearest treatment plant located on the shore of Lake Michigan to the east was at Michigan City, Ind., and the nearest one to the west was at Evanston, Ill., both of these plants having just been placed in operation. All other cities within this area, including Chicago, were then using Lake Michigan as a source of raw water for their municipal supplies and were then employing no other form of treatment but simple chlorination.

Whiting and East Chicago were operating fairly modern treatment plants, which had been constructed in the early 1920's. The plant at Whiting was, at that time, using pre-aeration and reaction basins of the series type, which gave the incoming water a serpentine travel around masonry baffles. These basins had a retention time of about 4½ minutes at the plant design rate of 2.5 mgd. From the reaction basins, the water in process of treatment passed through two "around-the-end" sedimentation basins which were generally operated in series, giving a retention period of about seven hours at the design rate. Following the sedimentation period, the water was filtered through six gravity type mechanical filter units at the standard rate of filtration. The filter boxes were of concrete, with a gutter along the side and with concrete wash water troughs. The underdrain system was the usual cast-iron pipe strainer system, set beneath graded layers of gravel (having an overall thickness of approximately 16 in.) which in turn supported the 22-in.-thick sand layer. Subsequent to filtration the treated water passed into a ground storage reservoir located beneath the filters. From there the city's distribution pumps took suction and conveyed the water through the distribution network to the various points of consumption. The plant used alum for coagulation and chlorine for sterilization, this being the extent of chemical treatment by the plant at that time.

Hammond Experience

In 1933 Hammond, Ind., began the design of a water treatment plant the construction of which was initiated in 1934. In the planning of this plant—in which one of the authors took an active part—a great deal of time was devoted to a study of the taste and odor treatment problem, with consideration being given to all of the methods then known. Included in the investigation was a study of the possibility of treating Hammond water for tastes and odors by mechanical means, using aeration in its various forms; by chemical means, using chlorine, ammonia, chloramines and ozone in accordance with the standard practices of the time; and by chemical and mechanical means, using powdered activated carbon and granular carbon filters. Because of the close proximity of the Whiting plant, it was only natural that considerable thought was given to the use of aeration at Hammond. Another plant which had been recently constructed on Lake Michigan at Waukegan, Ill., was also employing aeration (and still is) and the effects at that plant were likewise carefully studied. On the basis of the information then available, the final decision on the taste and odor control methods to be used at Hammond ruled out aeration. Chloramine treatment was adopted for the purpose of preventing the possible formation of chlorophenol compounds as the water entered the plant, and facilities were included in the original design to permit the use of powdered activated carbon at various stages of the treatment processes. Space was also

provided for the possible future installation of granular carbon filters and an ozone plant. After this plant had been put in operation in 1936, the authors, using mainly trial-and-error methods, were finally successful in developing means for controlling tastes and odors with powdered activated carbon. These procedures, which are still producing a palatable finished water, have been described in other papers previously published (1, 2).

Whiting Plant

By 1939, while Hammond was beginning to cope with its taste and odor problem and was consistently turning out a finished water having a threshold odor number of five or less, the Whiting plant found itself in the position of being unable to produce a drinkable water with the facilities at hand. The operators of the plant therefore began to give serious consideration to the improvement of their taste and odor treatment methods. This study took the form of a short period of observation of the methods in use at Hammond. Finally a small ozone generating and treatment pilot plant was set up in the Whiting water works to study the feasibility of the use of ozone as a taste and odor reduction medium.

The authors were much interested in the performance of this pilot plant. Although an acceptable drinking water was being produced at Hammond, there was difficulty in keeping the costs down, largely because of the great amounts of carbon being used.

The officials at Whiting decided, in a relatively short time, to install ozonation equipment for treatment of their entire supply. At the same time it was decided to discontinue the use of the spray type aerators which had been in operation at the plant for over sixteen years and were now considered to be of no benefit in combating the taste and odor problem. It was estimated that an expenditure of approximately $30,000 per million gallons of water to be treated would be required for the ozone equipment.

The ozone plant at Whiting was placed in operation in 1940 and a complete description of it may be found in the literature (3). The plant has been continued in operation at Whiting since that date and was regarded as the principal method of taste and odor treatment when the authors were employed as consultants in January 1947.

The first treatment the water received was an application of ozone, presumably for taste and odor control. Generally speaking, ozone was being applied at rates ranging from approximately 1.5 to over 5.0 ppm., depending upon the pumpage. When the ozone plant was operating at capacity, the dose would average between 5.0 and 5.5 ppm., again depending upon the pumpage.

The authors were requested by the city officials to assume responsibility for the plant operation with the objective of producing a palatable water in the shortest possible time and at the lowest possible cost.

Lake Michigan Pollution

The authors are unfamiliar with any water works located along the shore of the Great Lakes which has to deal with as bad a raw water as Whiting. Furthermore, it is doubtful that there are very many other water works in the country which are faced with a similar situation, including Hammond and East Chicago, whose water intakes are about a mile away from that of Whiting to the

west and east, respectively. How the character of Lake Michigan water can vary so greatly in such a small area has always been a major mystery, although the Hammond and East Chicago intakes extend further into the lake and are located in deeper water.

The raw water, which is pumped to the Whiting plant by the Standard Oil Co., is taken from Lake Michigan at a point approximately 2,000 ft. from the shore in a pocket of the lake formed by the steel and stone breakwaters at Indiana Harbor on the southeast and those at Calumet Harbor on the northwest. Into this pocket there was formerly discharged practically all of the sanitary sewage of Hammond, East Chicago, Whiting and most of Gary's, together with that of a number of smaller suburban towns. The sanitary sewage and wastes of all of East Chicago's and Whiting's industries and most of those of Gary and Hammond were also discharged into the pocket. These industries consist of some of the largest steel mills and oil refineries in the country, and also include soap works, corn products plants and other similar factories with organic wastes of a highly putrescible nature. The sanitary conditions existing in this area of the lake have been the subject of much attention by the U.S. Public Health Service and the state health departments of Indiana and Illinois. In the middle 1930's Indiana ordered the cities of Hammond, Whiting, East Chicago, Gary, Munster and Highland to cease pollution of the lake and to construct sewage treatment plants. To date all of these cities have complied with the order except Whiting and Highland. Whiting is still in the process of building the sewers which will enable its sanitary sewage to be diverted to the Hammond Sanitary Dist. for treatment. It will probably not be until the end of 1949, however, that Whiting finally stops discharging its raw sewage near the water intake.

In the early 1940's Illinois instituted legal action in the U.S. Supreme Court against Indiana, all of the cities mentioned above and most of the industries located in these cities, alleging serious contamination of Lake Michigan and of the drinking water supply of Chicago. The suit is still pending. In general, all of this agitation has tended toward a marked improvement of the sanitary conditions in this area of Lake Michigan, but the problem is far from solved. As an illustration, in March 1947 an extensive oil film in the vicinity of the Whiting intake was accidentally ignited and actually produced quite a large fire on the lake surface, which burned for several hours. Prior to their employment as consultants, the authors, on a number of occasions when the water was particularly bad, had observed threshold odor numbers in the lake water which ranged from 500 to 1,000. To attempt to manufacture palatable drinking water out of such raw material presented quite a difficult and distressing task.

Treatment Methods Tested

In approaching Whiting's taste and odor control problem, equipment was set up so that every known type of treatment could be considered. Likewise, laboratory control methods were instituted to permit evaluation of the taste and odor problem, and operations at the plant were altered in an attempt to cope with the rapidly and widely varying quality of the incoming raw water.

Threshold odors were generally determined at two-hour intervals, using samples taken from the incoming raw water, the effluent from the sedimentation basins just before the water passed onto the filters and the finished water as it left the plant. Sampling stations were located in the plant and the time of sampling was fixed so that the effectiveness of the treatment then in use could be traced as the water passed through the plant.

The plant operating data which were collected covered, among other items, applied ozone, ammonia, chlorine, coagulants and activated carbon.

It may be well at this point to state what the authors consider to be a satisfactory water from a threshold odor standpoint. The acceptability of a particular threshold odor number depends, in a measure, upon the type of water under treatment. At Hammond, the authors had always tried to maintain a value of 3 or better and usually were able to stay under 5. Accidents did happen, and there were times when the threshold odor of the finished water delivered to the mains was substantially higher than desired, but this occurrence was the exception rather than the rule. Other plants in the region, enjoying a better raw water supply, are usually able to keep the threshold odor value of their finished water under 5, which, the authors believe, makes for a satisfactory product. At Whiting, it was attempted to maintain threshold odor values at 5, and it was generally possible to keep the figure under 10 when the water was properly treated with activated carbon. Even at Whiting, however, values higher than 10 were considered to be definitely unsatisfactory.

Immediately after establishing methods for making routine tests, the use of activated carbon was begun on a plant scale, following the procedures successfully employed by the authors at Hammond, in an attempt to produce a palatable water quickly, as requested by the Whiting officials. An investigation was started on the possibility of reducing the taste and odor problem by providing a better means of coagulation and by devising methods for removing the heavy oil film and the entrained oils in the raw water. At the same time facilities were established for feeding chlorine dioxide on a plant scale.

An experimental granular carbon filter and an experimental ozone mixing tower were set up, suitable for small-scale testing. A known amount of water was passed through each of these units and careful readings were taken to determine how the water responded to the treatment. The amount of ozone was also varied to produce a fixed and predetermined residual at all times in the water being treated. In addition, laboratory work was done on free residual chlorination, but it was not tried on a plant scale for reasons to be given later.

Chlorinated Copperas

The attempts to improve the coagulation methods in use at the plant met with some success. Alum was being employed but the floc obtained was of the pin-point type. Because, at Hammond, the authors had had better success with ferric hydroxide, it was decided to try it at Whiting. It was also learned from R. J. Austin, an industrial-waste chemist of the Standard Oil Co., that ferric hydroxide was being used by that company as an adsorbing agent for the determination of dissolved oils in industrial wastes. Consequently iron salts were recommended as a co-

agulating agent and were applied in the form of chlorinated copperas because of the adaptability of the plant feeding equipment to its use.

Moreover, the authors began experimenting with dry fuller's earth in an attempt to remove the oily film which covered the surface of the incoming water. Superintendent Bartuska of the Whiting plant manufactured a clever device utilizing a sheet-metal inverted cone as the principal means for spreading the fuller's earth uniformly over the surface of the raw water. About 40 lb. of fuller's earth was used per million gallons of water treated and, although the results could not be quantitatively measured, it appears to have proved of material benefit. The slick, oily taste which hitherto had always been present in the finished water was completely removed. Also, the heavy oil film which existed most of the time on the water surface in the mixing basin was not present as the water passed on to the sedimentation basins.

Chlorinated copperas gave a much better floc than had previously been obtained with alum, even though less copperas than alum was used on an average. In the beginning copperas was fed at a rate of approximately 8.5 ppm., but the dose was varied (from 8.5 to 34 ppm.) in an attempt to determine that best suited for the plant needs. The normal dose was finally established at approximately 13 ppm. The iron particles were much larger than the pinpoint alum particles previously formed but this may have been due, in part, to the presence of the fuller's earth which was also creating an artificial turbidity in the water, as well as removing dissolved and surface oils.

It might also be well to mention that laboratory tests were made using activated silica with alum and that a heavy, large-particle floc was produced. Unfortunately, however, the required equipment was lacking to apply this treatment on a plant scale.

Chlorine Dioxide

Chlorine dioxide was used on a plant scale, generally being applied to the filtered water in dosages of about 0.4 ppm. chlorite. It was also applied at other points in the treatment process and at about double the dose, but without material success. When the chlorine dioxide was used on a plant scale, the water had first been treated with either ozone, powdered activated carbon or both, but the treatment never achieved material success.

Laboratory experiments with chlorine dioxide at much higher dosages on samples of the plant raw water showed that the threshold odor number could be reduced only to a certain point, beyond which chlorine dioxide became ineffective regardless of the quantity used. For instance, the threshold odor number of a particular water sample was lowered from 28 to 12 but no further reduction could be obtained with additional chlorine dioxide.

Free Residual Chlorination

Experiments were also performed to determine the effect of free residual chlorination. This work was done in the laboratory but, for the reasons noted below, was not tried on a plant scale. The chlorine demand of the raw water ranged from 20 to 50 ppm., which was far beyond the capacity of the chlorinating equipment at hand. Neither were there any dechlorination facilities at hand, should such a process have been necessary. It must be remembered that the raw-water quality fluctuated widely

and might, for example, have a chlorine demand of 30 ppm. for one hour, while during the following hour the figure might be down to 5.0 or up to 50 ppm. Although it might be possible to control such dosages by the use of highly skilled personnel, it did not seem wise to try it on a plant scale. An equally important objection was the laboratory indication that the effectiveness of free residual chlorination was limited to an odor reduction of approximately 50–60 per cent. Chlorine dioxide, free residual chlorination and ozone each produced in this water a burnt, acrid taste.

Chloramine

Chloramine was employed in order to reduce the possibility of the formation of chlorophenol tastes and odors. The authors feel that this treatment was, and is, undoubtedly justified. At the beginning of operations the ammonia-chlorine ratio was 4 : 1 but was later reduced to 3 : 1. It was found that the chloramine residuals persisted farther in the distribution system than did the free chlorine, and it was also possible to carry a substantially higher chloramine residual before chlorinous tastes and odors were detected. Moreover, the chloramine treatment seemed to be easier to control than the free-chlorine treatment, possibly because of the rapidly changing chlorine demand of the raw water.

Granular Activated Carbon

The results obtained from an experimental granular activated-carbon filter, set up at the beginning of the investigation, were quite disappointing. Known amounts of finished water taken from the plant filter effluent were passed at known rates of flow (generally 2 gpm. per square foot) through this filter, containing a 40-in.-thick layer of granular activated carbon supported on a layer of graded gravel 12 in. thick. After the filter had been in use for about 30 days, it suddenly ceased to show any effectiveness; it was therefore torn down and reconstructed, using new carbon. When placed in operation a second time, it soon lost its ability to act as an effective taste- and odor-reducing medium. This phenomenon can be attributed only to the fact that very heavy loads were placed on the filter at all times and that no means were available for backwashing it. In general, the threshold odor number of the water passing through the filter ranged from 20 to 100.

Powdered Activated Carbon

In the early stages of the work, the authors discovered what appeared to be a significant fact: a completely odor-free water could not be produced even by repeated distillation when using finished water that had been previously treated with ozone. On the other hand, it was possible to obtain a completely odor-free product from the plant raw water prior to ozonation. The use of ozone was therefore temporarily discontinued, and treatment was begun on a plant scale with powdered activated carbon alone. The carbon proved to be a flexible odor control medium, and it was found that, *if enough of it was added to the water,* the threshold odor value could be lowered to practically any desired point. Figure 1 shows the effect of this treatment during a period of 21 days of plant operation in April 1947.

Although the graph indicates a fairly successful operation, it was often quite difficult to hold to these standards. The chief disadvantages in applying the

large dosages required at Whiting are mainly due to the awkwardness of handling large amounts of carbon. First, it is physically very hard to apply such dosages as, say, 140 ppm. of carbon, which represents 35 bags per million gallons of water treated. The unloading of such a quantity is a formidable job for any water plant even if the chemical feeders are adequate. Second, the feeding of such carbon dosages can (and did) produce quite a difficult public relations problem, as it is practically impossible to prevent the carbon from passing the filters without more adequate coagulation and settling facilities than were available at Whiting. By extremely careful plant operation, fair success was achieved in preventing carbon from passing the filters, but there were times when it proved practically impossible. Examination of Fig. 1 will indicate that the raw water during the period covered had an average threshold odor number of 81, while the average for the finished water was 9.0, showing that 89 per cent of the odor had been removed. During this period the carbon treatment alone was used for taste and odor control. The average dosage was 84.5 ppm., or 1.17 ppm. of carbon per threshold odor unit removed. Originally the carbon treatment was carried out in combination with ozonation. The carbon was applied at a point about midway through the sedimentation basins in order to take advantage of whatever odor reduction could be obtained from the chlorinated copperas and fuller's earth being used as coagulants. Later, as already stated, the use of ozone was discontinued, but the carbon was still applied at a point approximately midway through the sedimentation basins. However, when the threshold odor of the raw water would begin to approach values of 30 and over, the carbon feed was split by applying most of the required dose in the reaction basins and the balance in the sedimentation basins, to prevent large amounts of carbon from carrying over on the filters.

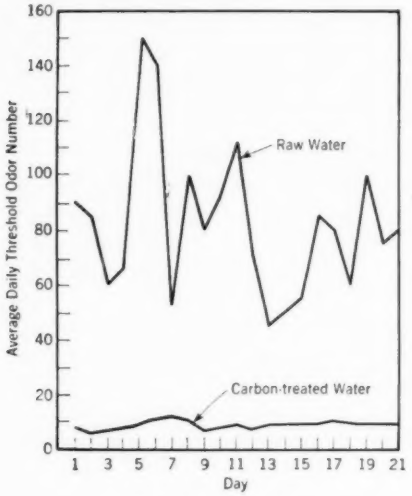

FIG. 1. Activated-Carbon Results

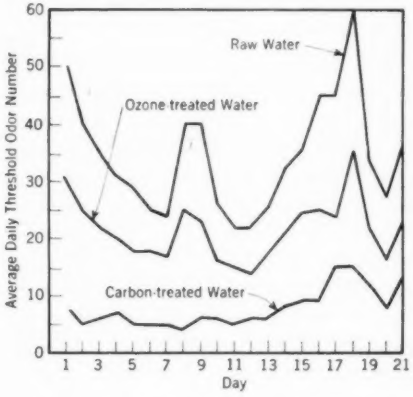

FIG. 2. Ozone and Carbon Comparison

Ozone Treatment Evaluation

Before commenting on the effect of the ozone treatment as a taste and odor control medium at Whiting, attention should be called to the methods which were in use at the plant. All of the incoming water to the plant passed through two ozone diffusion towers operating in parallel. Ozone was introduced at the bottom of these towers and bubbled upward through the incoming raw water, which flowed downward through the towers and then into the plant, where it was cascaded into the reaction basins. This was the first treatment the water received, and there were no other possible points of ozone application.

The capacity of the ozonators was approximately 75 lb. of ozone per day, which, for the pumpage prevailing during the period under study, limited the ozone application to approximately 4.8–5.4 ppm. The original installation consisted of five plate type ozone machines, each having a rated capacity of 10 lb. of ozone per day. Three of these units had recently been converted to tube type machines, each with a rated daily capacity of 25 lb. of ozone. The remaining two machines of the original installation were lying idle and had not been changed over.

It was the general practice to ozonate, when possible, to a slight residual of approximately 0.1 ppm., using orthotolidine as the indicator, with the usual chlorine standards. During the period under investigation, however, at times of unusually bad water, the ozone applied would not give a residual to the ozonator effluent, although the generators were stepped up to capacity.

Observations over a 60-day period indicated that approximately 14.0 kw. of electric energy was needed to produce 1 lb. of ozone (according to Bartuska (3) the amount needed is 16.28 kw.). Whiting purchased this energy on a power schedule based on a "demand" charge. A review of the power bills at the time showed that the cost of the energy averaged 1.5¢ per kw., which, applied to the above data, indicates a power cost of 21¢ to produce 1 lb. of ozone. If to this figure are added all of the other operating costs of the ozone plant and its auxiliaries plus the fixed charges, the price of producing 1 lb. of ozone at Whiting would probably go over 35¢.

Figure 2 shows the comparative reduction of the threshold odor value of the water treated with ozone and activated carbon, applied consecutively on a plant scale. During 21 days in March 1947 ozone reduced the average threshold odor value of the raw water from 36 to 23, thereby removing 36 per cent of the odor. At all times during the period sufficient ozone was applied to produce a residual in the effluent from the ozonator. Immediately following the ozone treatment carbon was applied to the water as it entered the reaction basins. The carbon further reduced this average value of 23 to 8, thus removing 42 per cent of the original odor of the raw water, or 65 per cent of the odor in the ozonator effluent.

To facilitate further evaluation of the ozone treatment, a mixing tower suitable for small-scale testing was set up at the plant. The tower was 6 in. in diameter and 18 ft. long and received ozone in known quantities, bled from the main plant ozone line. The ozone was was then applied countercurrent to the flow of water (which was metered) in order to simulate actual plant conditions. The operating procedure generally was

to carry a 0.2-ppm. ozone residual in the experimental-unit effluent.

The results of the work with the ozone pilot plant appeared to indicate that the use of ozone for taste and odor control at Whiting is limited. Generally speaking, although experience showed that ozone was capable at times of improving the quality of the raw water, it did so only in a limited degree and acted in much the same manner as other oxidizing agents, like chlorine and chlorine dioxide. All of the oxidizing agents experimented with, including ozone, were capable of reducing the threshold odor value of the water, but there was a limit beyond which they proved to be ineffective, whatever the amount used. For example, it was found repeatedly that ozone would reduce the threshold odor value of the raw water from, say, 100 to 50. Below 50, however, no further reduction could be made, no matter how much ozone was used. This phenomenon held true regardless of the initial threshold odor of the water in all of the work done.

The authors have not elaborated on the cost of the various threshold odor treatment methods tried at Whiting for the simple reason that they were instructed to determine first whether Whiting's water could be successfully treated. Fairly close estimates were made of the unit cost of ozone production, and these figures have previously been given. The overall efficiency of the ozone plant and the actual day-to-day poundage of ozone produced were difficult to determine on the basis of information available. A comprehensive and impartial evaluation of the Whiting installations and of this form of water treatment will only be forthcoming when the necessary data are carefully and scientifically collected.

In general, it may be said that when the threshold odor value of a water of this type gets much beyond 100 and consistently remains there, a serious doubt arises as to whether or not any treatment can be economically justified. In 1947 observed threshold odor values of the Whiting raw water were occasionally as high as 1,000. During 1948 and 1949 threshold odor values of the raw water have been reported by the plant personnel to have reached peaks as high as 7,000. It is obviously impossible to treat such a water with success.

Conclusions

The work of the authors at Whiting was necessarily quite limited, principally because of the time element involved—a period of five months. The conclusions drawn from this experience, which are enumerated below, should therefore be received with caution and should be evaluated with this limitation firmly in mind:

1. Dry fuller's earth applied to the plant influent proved to be successful in removing the heavy oil film present on the raw-water surface.

2. Chlorinated copperas was successful in reducing the dissolved-oil content of the water. In the authors' estimation, the use of fuller's earth and chlorinated copperas played a very material part in removing the slick, oily taste which had always been present in the water.

3. Chlorine dioxide applied on a plant scale did not effectively reduce the threshold odor of the water. Free residual chlorination did not appear to yield satisfactory results, but chloramine treatment gave promise of success.

4. The results obtained through experimentation with a granular carbon filter proved disappointing. This filter was unable materially to reduce the threshold odor of the water passed through it for any great period of time. The failure is largely attributed to the fact that the filter could not be properly and periodically cleaned.

5. Ozone proved incapable of combating the taste and odor problem. Although ozone improved the quality of the water to a limited degree, it did so in about the same way as other oxidizing agents.

6. The use of activated carbon was the only means by which the authors were able to produce a satisfactory water from a highly polluted supply. There was difficulty in handling and feeding the dosages required, which at peak periods amounted to 140 ppm. of activated carbon. Trouble was also experienced with carbon passing the filters.

7. In the authors' opinion, it is beyond reason to expect even the best equipped and most modern plant to produce a satisfactory drinking water using raw water of the quality supplied to the Whiting plant. Furthermore, it is doubtful that a successful treatment could be economically justified under these conditions for a prolonged period.

Acknowledgment

The authors wish to express their appreciation to all who cooperated in the performance of their work and tests. Those to whom the authors are principally indebted for their assistance are: the operating staff of the Whiting water plant, headed by Steve Dado, the present plant superintendent; J. F. Bartuska, the former plant superintendent; Stephen L. Pieters, City Engineer of Whiting; Victor Hann, of Ozone Processes Div., Welsbach Corp.; H. F. Laughlin and D. C. Colebaugh Jr., of Industrial Chemical Sales Co.; R. N. Aston, of Mathieson Alkali Works; C. C. Abplanalp, of Wallace & Tiernan Co.; R. J. Austin, of Standard Oil Co., and his associates; as well as numerous others who contributed valuable aid.

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Revision of Recommended Practice for Tank Inspection, Repair and Repainting

The following changes, approved by the Association's Board of Directors on September 26 and 28, 1949, are to be made in the A.W.W.A. "Tentative Recommended Practice for Inspecting, Repairing and Repainting Elevated Steel Water Storage Tanks, Standpipes and Reservoirs—7H.2-T":

1. Introduction, Paragraph 10 (of the numbered paragraphs). Add the phrase in italics: *"While the use of the contractor's contract form is not recommended,* if the owner chooses to engage in letting contracts for painting and repair on contract forms other than his own, he should first submit them to his attorney, asking him to study them carefully to see: . . . ."

2. Sec. 2A–1.4—Draining of Tank. The second sentence is changed to read: "The inside surfaces should be thoroughly washed down by the owner to remove slime from wall surfaces and loose deposits and dirt from the tank bottom before the inspector arrives."

3. Sec. 2A–2.1—Condition of Paint. Item (1) is changed to read: "Rough approximation of per cent of rust area."

4. Sec. 2A–2.2—Pitting. Insert the phrases in italics: "Determine and report upon the extent and depth of pitting *in the area selected, scaled and cleaned by the inspector. The dimensions and locations of each area scaled and cleaned are to be reported.* The extent *of pitting found* should be described both as to location and character. The record of depth of pitting should be *as specific as practicable* as to location, area affected, whether blotchy, deep, pin-point or general corrosion."

5. Sec. 2A–2.3—Type of Repairs. In the second sentence, add the phrase in italics: "If they can be repaired by patches, the inspector shall specify, *to the extent practicable,* the size, location and number of patches."

6. Sec. 2A–3.1.10—*Paint.* In Item (5), insert the phrase in italics: "The condition of the paint and metal inside of the tank shell, *based on the areas carefully examined and other information gained by the inspector."* At the end of Item (9), insert the phrase: *"of the tank."* At the end of Item (10), insert the phrase: *"of the riser pipe."*

7. Sec. 2A–3.1.11—*Rivets.* Insert the phrase in italics: "Report, *by selecting, scaling and examining suitable areas,* the condition of the rivets at lap joints and post connections."

8. Sec. 2A–3.1.12—*Metal.* Insert the phrase in italics: "Report, *by selecting areas to be examined,* the condition of the metal between the rivets at the laps and at the post connections."

9. Sec. 2A–3.1.14—*Prior Painting.* Insert the words in italics: "(1) When was the tank *reported to have been* last painted? (2) What material was *reported* used?"

10. Sec. 2B–1.2—Inspection Recorded. In the second sentence, insert the phrase in italics: "The bidders shall familiarize themselves with the report and the conditions of the structure and, upon request to the owner *and under such conditions as the owner may prescribe,* may make such further inspection as they consider necessary prior to submitting proposals."

11. Sec. 2B–1.3—Work to Be Itemized. In the first sentence, insert the words in italics: "The owner shall itemize repair work by units, such as the number of patch plates to be welded to the structure and their *approximate average* area; the lineal feet of welding *or calking* to make the seams watertight; . . . ."

12. Sec. 2B–3—Watertightness. In the last sentence, add the phrase in italics: "Payment for repair work shall not be made until and unless the job is watertight *in the areas in which the contractor was called upon to make repairs to secure watertightness."*

13. Sec. 2C–1.2—Damage to Tank. The third sentence is changed to read: "If, in the process of removing old paint or carrying out the work specified in the contract, any leaks develop which in the opinion of the owner were caused by negligence, lack of skill or other act or omission on the part of the painting contractor, such leaks shall be repaired by the painting contractor without additional remuneration; . . . ."

Remodeled Cornell University Filter Plant

By F. R. Georgia

A contribution to the Journal by F. R. Georgia, Supervisor of Water Works, Cornell University Filter Plant, Forest Home, Ithaca, N.Y.

THE growth of enrollment following the war made it necessary to increase the capacity of the Cornell University Filter Plant. The original plant had three filters, rated at 500,000 gpd. each; a mixing basin with over-and-under and around-the-end baffles; and three settling basins operated in series, with a total capacity of approximately 400,000 gal.

It was decided to build an addition to the plant that could house three more filters—only one of which was to be completed immediately—and that would provide better laboratory facilities. It was also decided to install a mechanical flocculator in the mixing basin in place of the around-the-end baffles, with the hope that better flocculation would make it unnecessary to increase the capacity of the settling basins. These changes were completed in 1948 and there has been an opportunity to evaluate the results. A flow diagram of the enlarged plant is shown in Fig. 1.

Mechanical Flocculation

The flocculator installed (Fig. 2) was of the walking-beam type, originated and sold by the Stuart Corp. and manufactured by the Ralph B. Carter Co. The flocculator consists of two units, each having a U.S. Varidrive * connected through a gear reducer (manufactured by Philadelphia Gear Works) to the walking beam. The first unit has a 5-hp. motor and can be operated at any rate from three to nine cycles per minute. The second unit has a 3-hp. motor and a speed range of two to six cycles per minute.

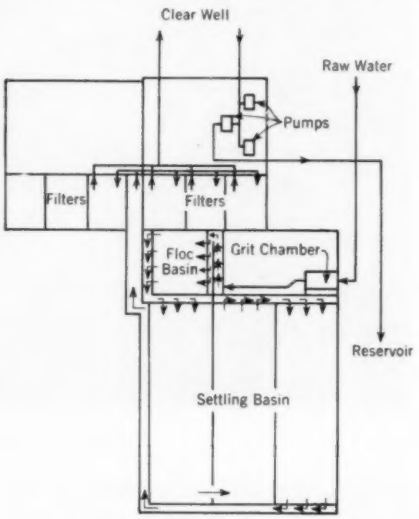


FIG. 1. Filter Plant Flow Diagram

On entering the basin, the water passes along a channel with over-and-under baffles, the last of which is a weir that gives rather good, quick mixing. Distribution across the basin is obtained by a concrete wall, over which the water can be seen flowing in Fig. 2.

A baffle was installed between the two flocculator units with a 1-ft. hori-

* Made by U.S. Electrical Motors, Inc., Milford, Conn.

zontal slot running across the basin at the mid-depth of the water. The baffle had not been built when Fig. 2 was photographed but can be seen in Fig. 3, which shows the basin drained. Also visible are the inverted troughs that produce the agitation. All underwater parts of the equipment were made of silicon bronze (Herculoy * and Everdur †), which was chosen because the equipment cannot be taken out of service for painting.

The walking-beam type of flocculator has certain advantages—there are no bearings in contact with water and no stuffing boxes are required to isolate them from the water. This type was readily adapted to the existing basin.

It should be emphasized in any discussion of flocculation and flocculators that, regardless of the equipment employed, it is still necessary for plant operators to feed coagulants at proper rates and to change the rates to meet changing water conditions. Unfortunately, the data to be presented contain several examples of improper dosage.

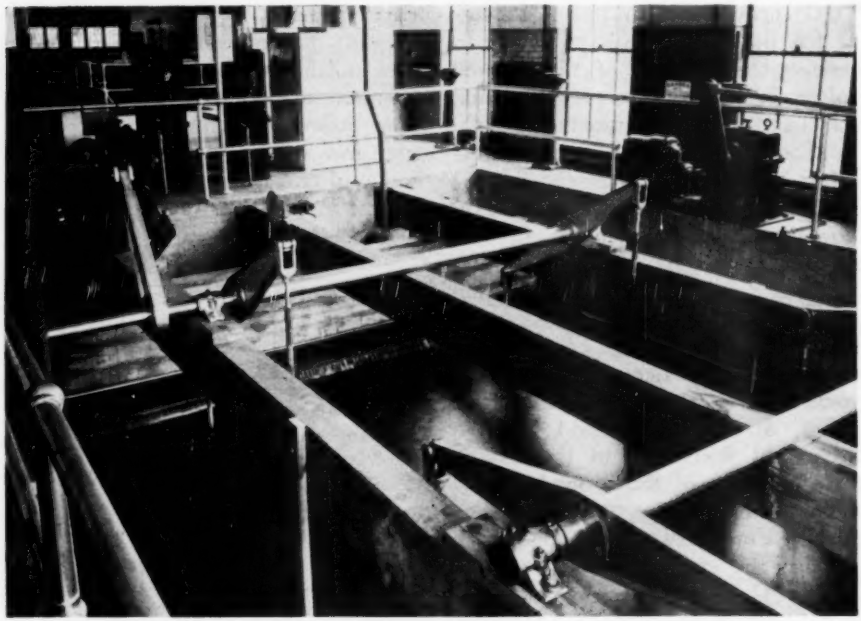


FIG. 2. Flocculation Basin

The source of raw water is a small surface stream that is subject to sudden, large fluctuations in runoff and suspended matter. During the period under consideration the range of raw-water turbidities was from 1.4 to 1,000 ppm., with frequent changes of several hundred parts per million in the space of an hour or two.

Perhaps as good a measure as any of what has been accomplished by flocculation and settling is the turbidity of the settled water as it goes to the filters. In

* Made by Revere Copper and Brass Co., New York.

† Manufactured by American Brass Co., Waterbury, Conn.

Table 1, data for three periods are given, from which certain comparisons and conclusions may be drawn. The tabulation contains maximum, minimum and average values for the amount of water treated and for the turbidities of the raw and settled water. The first section of the table covers a full year prior to installing the flocculator. Between September 18 and 21 of this period the around-the-end baffles were removed from the mixing basin and the distributing wall was built in preparation for the installation of the flocculator. Coagulation during this period was with alum and lime, with some sodium aluminate (*see* Table 2).

The second section of Table 1 covers the period from March 16, 1948, when the flocculator was put in service, to the end of the year. The baffle was installed between the two units on December 22, 1948. Coagulation was with alum and lime.

The third period runs from January through August 1949. Alum was used as the coagulant, with soda ash added when needed.

With a water supply taken from a small stream, it is, of course, impossible to make exact comparisons of results obtained for different periods. Some conclusions of interest may be reached, however.

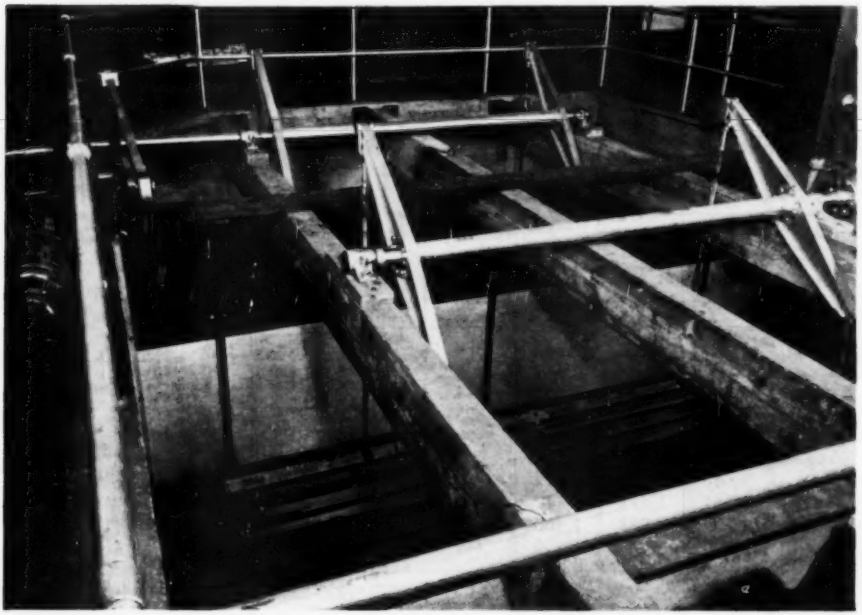


FIG. 3. Flocculation Basin Drained

Seasonal variation in consumption of water at Cornell is largely a result of vacation periods and thus differs from that of most municipal plants. Although the water demand at the university has more than doubled in the last ten years, the peak has not yet been reached. This growing demand is reflected in the values given in Table 1. The high values for June and July 1948

TABLE 1—*Turbidity Data, 1947–49*

Period	Water Treated *1,000-gpd. units*			Turbidity—*ppm.*					
				Raw Water			Settled Water		
	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
1947									
Mar.	1,365	1,020	1,243	140	1.7	25	11	2.1	4.1
Apr.	1,300	887	1,165	220	3.8	28	22	1.6	3.9
May	1,388	1,021	1,267	700	5.0	45	110	1.1	6.6
June	1,909	826	1,159	650	2.6	37	10	0.5	1.9
July	1,339	939	1,146	90	2.3	9.5	90	0.5	3.9
Aug.	1,274	851	1,065	85	2.3	12	16	0.4	2.4
Sept.	1,386	860	1,214	145	1.0	9.5	3.5	0.6	1.0
Oct.	1,410	1,224	1,352	180	1.8	15	2.5	0.6	1.5
Nov.	1,478	1,035	1,368	105	2.7	13	7.0	1.7	3.9
Dec.	1,486	713	1,287	200	4.0	16	16	3.0	5.0
1948									
Jan.	1,428	1,348	1,395	6.2	1.6	3.5	5.0	2.6	3.7
Feb.	1,435	1,191	1,391	180	2.0	17	14	2.4	5.6
Mar.*	1,454	1,003	1,339	380	10	121	19	2.6	7.4
Apr.	1,404	1,042	1,334	60	3.2	15	10	1.8	3.4
May	1,509	1,362	1,443	44	3.4	15	19	1.5	3.8
June	2,190	1,310	1,642	95	2.1	9.8	10	1.0	2.1
July	2,456	963	1,798	70	3.6	9.1	9.0	1.0	2.7
Aug.	1,510	591	1,141	900	2.7	43	27	0.5	2.5
Sept.	1,646	767	1,212	10	1.4	4.1	2.5	0.6	1.2
Oct.	1,551	1,271	1,472	40	1.5	6.0	3.0	0.7	1.7
Nov.	1,509	988	1,360	850	1.5	41	25	1.1	4.9
Dec.†	1,529	739	1,279	340	1.8	15	5.0	1.5	2.7
1949									
Jan.	2,365	1,019	1,495	260	4.3	20	9.5	2.4	4.4
Feb.	1,595	1,091	1,404	125	3.4	18	8.0	2.6	4.1
Mar.	1,698	1,135	1,477	90	3.5	11.9	6.5	2.2	3.9
Apr.	1,692	859	1,500	73	2.6	11.9	4.3	1.2	2.1
May	1,799	1,272	1,576	40	2.1	6.9	6.5	0.8	2.0
June	1,647	1,065	1,450	1,000	2.2	42	15	0.9	2.7
July	1,635	1,098	1,419	30	3.3	7.6	4.3	1.0	1.7
Aug.	1,596	1,063	1,394	950	2.9	37	6.0	0.6	1.5

* Flocculator started March 16, 1948. Data for March 1–15 not included.
† Baffle installed between flocculator units December 22, 1948.

resulted from furnishing water to Ithaca, N.Y., when the city's raw-water line was damaged by a landslide.

In discussing turbidity results for settled waters, it should be remembered that the addition of a coagulant first increases the amount of suspended matter, and both the original and this added material must be flocculated and settled out to get proper results.

An examination of the turbidity results obtained on the settled water for the first period will show that the average values are rather good but that on several occasions the maximum values are bad. Some of these, as for May and July, are undoubtedly the result of improper coagulation. Removal of the around-the-end baffles in the middle of the period did not have any appreciable adverse effect on the results.

During the second period, with the flocculator in operation, the average values for settled-water turbidities are good, but there are still some poor maximum values.

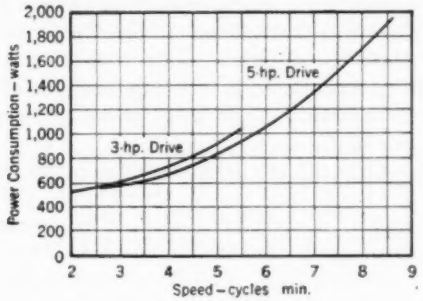


FIG. 4. Power Consumption

The third period also shows good average values and, with one exception, the maximum values are satisfactory. The better results are to be ascribed to the baffle between the flocculator units —which prevents skimming—and the substitution of soda ash for lime as an aid to coagulation.

The introduction of mechanical flocculation has made possible improved operating results even though the load on the plant was increasing and the capacity of the settling basins was not enlarged. At the same time Table 2 shows a decrease in the amount of coagulant used.

Both of the flocculator units are equipped with variable drives, as previously mentioned, with the speed range of the first unit higher than that of the second. The higher speeds have not been found useful, and it is felt that, although some variation in speed is desirable for different water conditions, the advantage gained is outweighed by the additional cost. Fixed drives of four cycles per minute for the first unit and three cycles per minute for the second would probably be best at the Cornell plant.

H. T. Zimmerman, of the Ralph B. Carter Co., made some measurements of power consumption on the two units shortly after they were installed. His results are shown by the curves in Fig. 4. The equations for these power curves, which were developed by Howard Golub (1), are:

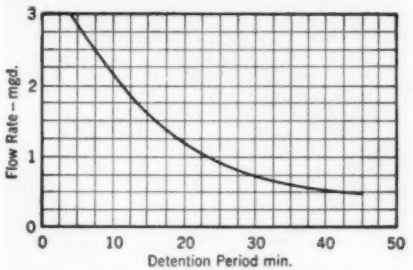


FIG. 5. Flow Rate–Detention Period Curve

For the 3-hp. flocculator:

$$\text{Watts} = 38.5\ (\text{cycles/min.} - 1.25)^{1.8} + 500$$

for the 5-hp. flocculator:

$$\text{Watts} = 55\ (\text{cycles/min.} - 2.6)^{1.8} + 580.$$

TABLE 2

Average Rates of Feed

Period	Avg. Rate of Feed—*ppm.*			
	Alum	Lime	Soda Ash	Sodium Aluminate
Mar. 1947–Mar. 1948	30.1	2.7		0.5
Mar. 16, 1948–Jan. 1949	26.3	5.1		
Jan. 1949–Sept. 1949	24.8		1.4	

Operation costs are much lower for the slower rates. No attempt has been made to compute the cost of operation per million gallons of water treated, since the rate of flow through the basin is subject to rather wide variation, while the rates at which the flocculators are operated remain nearly constant. The flocculator basin proper has a volume of 15,600 gal. The detention period is plotted against flow rates in Fig. 5. The plant has been operated successfully at rates as high as 2.5 mgd., which gives only eight minutes in the flocculation basin and about four hours in the settling basins. This rate was attained by operating the present four filters above their rated capacities.

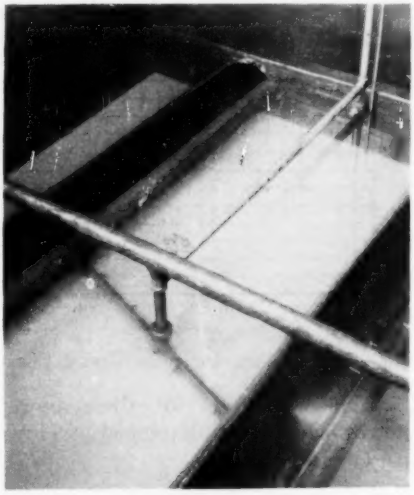


FIG. 6. Wash Water Troughs

In 1942 the author (*2*) described the reconstruction of one of the filters at the Cornell University Filter Plant, using Norton * porous plates for the underdrain system, Anthrafilt † for the filtering medium and Palmer Agitators ‡ for surface wash. The two remaining old filters have since been rebuilt in a similar manner, and the one new filter completed is also of this construction, which implies continued satisfaction with this type of filter.

The wash water troughs used in the new filter may be of interest to others. They were made from lengths of 20-in. steel pipe, from which a longitudinal section was cut to leave an opening 14 in. wide. After the troughs were in place, metal lath was stretched over the outside and hooked over the lips of the troughs. Both the inside and the outside of the troughs were then coated with a 1 : 1 cement and sand mortar containing a liberal amount of Ironite.§ Care was taken to obtain lips that were smooth and level. The cement was then coated with two applications of Bituplastic.‖ The troughs are shown in Fig. 6.

Although a circular section is probably not ideal for wash troughs, the author is convinced that it is much superior to the flat-bottomed U-shape commonly used. Flat-bottomed troughs tend to set up eddy currents in the rising wash water. Such currents are not in evidence with the circular section and a much better flow of the wash water to the troughs is obtained. Up to the present the coating applied to the troughs has stood up well and appears to have protected them from rusting.

References

1. GOLUB, HOWARD. A Study of Flocculation, With the Aid of an Overhead Drive Flocculator. M.S. in Eng. Thesis, Cornell Univ. (1948).
2. GEORGIA, F. R. Some Observations on Filters. Jour. A.W.W.A., **34**:1055 (July 1942).

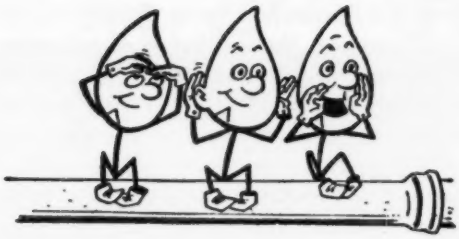
* Made by Norton Co., Worcester, Mass.

† A product of Anthracite Equipment Corp., Wilkes-Barre, Pa.

‡ Manufactured by Palmer Filter Equipment Co., Erie, Pa.

§ A product of Crest Mfg. Co., Long Island City, N.Y.

‖ Made by Koppers Co., Inc., Pittsburgh.



Percolation and Runoff

Worry over water shortage is world-wide these days. Last month in England and Italy, autumn rains of cloudburst proportions caused freak floods which did millions of dollars of damage, but didn't touch the drought. At Dartmouth, England, for instance, a local storm was so severe that it backed up the River Dart through the city's storm sewer system and created the spectacle of fish swimming in the gutters, while in nearby London a 4.4-bil.gal. reservoir remained bone dry. In Germany, the Rhine was so low that barges could carry only a third of their usual load for fear of grounding. And back home in New York City, water supply reservoirs were down to half capacity, setting in motion a number of emergency conservation measures in city departments and pleas for voluntary consumer water saving. Critical as they are, however, these shortages are nothing that a good wet winter couldn't cure.

Out in California, on the other hand, the problem is more serious. There the summer dryness could be blamed only for aggravation, not creation, of the catastrophic shortage. Even under the best conditions, expanding its economy and population as rapidly as it is, California could not hope to find water enough within its borders to supply itself. And such help as it has already obtained from the Colorado River has been more than offset by the increases in consumers and consumption since that source was tapped. Even during the ten wet years which preceded the last three dry ones, it is said that Californians were using more water than the rains provided. Thus the state is more than desperate in its efforts now to find more water somewhere, not only to provide for present needs but to keep its boom in motion.

Among the hopes held out have been the cooperative development of an intensive conservation program to make the best use of what water there is and the scientific development of new sources—such as Oregon's Columbia River, such even as the Pacific Ocean. And even now the state and the federal Bureau of Reclamation are giving serious study to the project

(*Continued on page 2*)

(*Continued from page 1*)

which would pipe and pump water from the mouth of the Columbia some 1,100 miles south. Now, too, intensive research is being directed at the possibility of devising practical equipment for the distillation of sea water on a large enough scale to supply municipalities and irrigation districts. Only the other day, as a matter of fact, the President asked Congress for half a million dollars for a federal project to carry out such research on a national scale.

What will be the ultimate answer, we hesitate to predict. Not being Califobes, we won't suggest that a reduction of population is the only possible way. Appreciating the past accomplishments of science and of engineering in particular, we can't write off either the Columbia River Aqueduct or, entirely, distillation. We've already, and apparently so have Californians, given up the idea that "cloud-busting" can contribute any more than a drizzle to the flood that's needed. But where there is a will—and no one has ever accused California of being intestate—there will undoubtedly be found a way.

Meanwhile, in the interest of best using the water that's available, we've seen no more down-to-earth suggestion than the following one received by Franklin Thomas, Chairman of the Colorado River Board of California, from a thoughtful constituent:

Dear Sir:

I see by the papers that we are always fighting for water. Arcadia is shut off part of the time. Monterey Park is also shut down for some things between 3 and 7 p.m. Also other towns are in trouble. Now, we could save millions of gallons of water every day if everyone would save one flush of the toilet a day. You know as well as I do that half the flushes of a toilet are unnecessary.

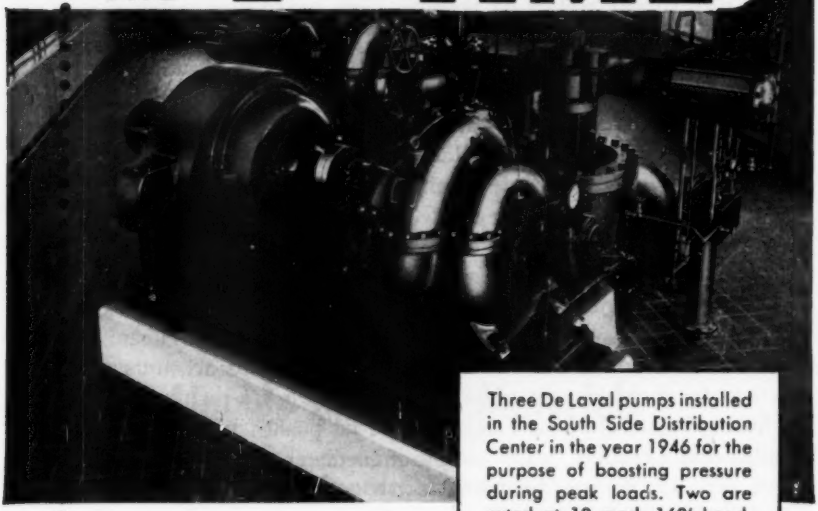
Countless thousands of women are like my wife (and I can't get her to see it). She can't even look at the toilet without flushing it. She blows her nose on a kleenex, throws it in the toilet and flushes it. Combs her hair, takes out three or four hairs from the comb, drops them in the toilet and flushes it. Now, most women are like that. They also waste water in the kitchen. We are spending money to build dams, pipelines, etc.—why not spend a little money to advertise to save water?

As I say, if every one would only save one flush, think of the millions of gallons of water that could be saved every day.

As a matter of fact, such a campaign, under some such slogan as "Don't Be a Fourflusher When Only One Will Do," might well be adopted wherever shortages plague, for whatever reason. And if it won't attack the real basis of California's water worries, it will at least make consumers conscious of the fact that almost 50 per cent of their normal domestic consumption is a straight flush.

(*Continued on page 4*)

FOR THE 7th TIME



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WW-8

(*Continued from page 2*)

A Superior Service Award was presented by the Dept. of Agriculture to its Div. of Watershed Protection and Management at the Southeastern Forest Experiment Station on Sept. 9. The award is in recognition of the research work done at Coweeta Laboratory in establishing the quantitative effects on stream flow of various treatments of watershed lands. A review of some of the findings of the station's staff appeared in the May 1947 Journal (Vol. 39, p. 443) in a paper by Joseph A. Lieberman entitled "Water Resource and Watershed Management Research in the Southeast." Accurate measurement and the maintenance of scientific records were begun at the Coweeta Laboratory 15 years ago.

Man's impatience, which we have deplored before on numerous occasions, never had a more tragic demonstration than that which took place in the Hollywood gas company office last October 3. One William Holmes, a conscientious consumer who believed in settling his accounts promptly, was waiting at the counter to pay his gas bill when a man in an obviously big hurry to get rid of his money rushed in, pushed past Holmes and demanded that a cashier "wait" on him immediately. The scuffle which followed was not only understandable but unfortunate inasmuch as it resulted in the death of Mr. Holmes. Thus, the impatient one ended up not only first in line, but first in the lineup, booked in jail upon suspicion of manslaughter. And neither bill was paid.

Of the many morals which occur to us, "don't pay your bills" isn't one, but a strong case might well be made out for "pay your bills by mail." Certainly there wouldn't be much point in advising "don't use gas" or even "don't live in Hollywood," for we, as a New Yorker, are well aware that the fatalities in a similar instance in our fair city would have been multiple. At any rate, remembering our own well elbow-calloused ribs and our relatively successful unimpatience in this den of metropolitan irritation, we must again recall the fable of the tortoise and the hare, pointing out, of course, the advantage not only of speedlessness but of a thick shell.

(*Continued on page 6*)

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(*Continued from page 4*)

Fish tales are forever flopping in our face. Much as we'd like to avoid even reference to the intricacies of ichthyology or the alleged pleasures of piscatology, we're always being reminded of our elemental concern with the cold-blooded, worm-eating creatures which infest our waters. Thus we accept the role of talebearers and count every tale a cross.

First fisherman of the water works realm—at least in our books—is one Wendell R. LaDue of the Akron, Ohio, water department. Only last month, ex-prexy La Due received a fine letter of commendation from the powers that be in Akron for his part in making the 1949 Fishing Rodeo, for children under fishing license age, a big success. That "part," incidentally, included securing prizes, furnishing personnel to handle the registration, assisting the young fishermen in baiting their hooks and untangling their lines, rendering first aid and, beyond that, furnishing several thousand mature fish from the department's Lake Rockwell as fair game. And some two months previous the same fish fancier became one of the two honorary members of the 30,000-member United Conservation Clubs of Summit County, Ohio, by virtue of his good offishes in promoting conservation.

Fresh fish news, too, has arrived from Orange, N.J., where state hatchery men recently made their triennial raid on the Orange Reservoir with the purpose of thinning out the reservoir's fish population and restocking Branch Brook and Weequahic Parks in Newark. Pictures (see cover) of the large haul of perch, pickerel, bass and carp undoubtedly made many mouths water and casting arms itch. As for us, Ugh!

Finally, from Easton, Pa., came still another story of thousands of fish—dead—floating on their backs down the Lehigh River from a polluted upstream area presumed to be at Bethlehem. Second such fish kill in a month, this calamity had the state fish warden, water works men and the bureau of sanitary engineering water sampling and post-morteming to trace the guilt. In this case, though, we confess to mourning with the fisherman, though perhaps more for the crime than the crimed against. And our mourning stems less from the fact that our distaste for the species Pisces is accentuated in death, than from the knowledge of what the same pollution can do to our water supplies. As a matter of fact being quite big about the whole thing, we'll admit that we like fish in their place and would move mountains not only to keep them there but to keep them healthy there.

The use of sound waves—audible and inaudible—for water treatment (see Sept. 1949 JOURNAL, p. 74) gained another foothold when the Ohio River Valley Water Sanitation Commmission embarked upon a study of the possibility of elimination of phenol wastes by the use of ultrasonics. An investigation into soil pollution was also instigated.

(*Continued on page 8*)

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(*Continued from page 6*)

Devoted to water conservation in the West is the August 1949 issue of *The Reclamation Era*, official publication of the Bureau of Reclamation. Keynoting the issue is the self-explanatory title of an article by Commissioner Michael W. Straus: "Conservation (Full Utilization) of Water." But more spectacular is an article on salt water distillation by Oscar L. Chapman, Undersecretary of the Interior, which fans the blaze that some day may be boiling the ocean. Although he underlines the necessity for more efficient use and reuse of water, and also suggests diversion of some of the surplus Columbia River water to California, his chief attention is turned to the Pacific Ocean, viewed by some as the West's "last water hole." Artificial control of rainfall he considers "a rather dubious" possibility. Although distillation is still too expensive to be used for municipal supply—except perhaps in emergencies, Chapman points out that the present cost of water produced by the largest units, including fuel, depreciation and all operating costs, has been reduced to a range from 55¢ to $1.50 per 1,000 gal. Since the beginning of the war, their efficiency has been increased eight times. And bills are now pending in both Senate and House which would authorize research and pilot plant projects by the Interior Dept.

(*Continued on page 10*)

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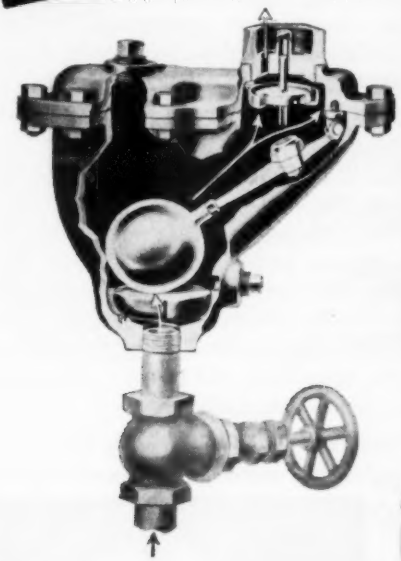


VENTING
Permits escape of large quantities of air as pipe line is being filled with water.

AIR INLET
Permits air to enter pipe as line is being drained.

PRESSURE AIR RELEASE
Allows accumulated air under pressure to escape from high points of pipe lines.

YOU GET ALL 3 SERVICES FROM THE

RENSSELAER

AIR and VACUUM and AIR RELEASE VALVE

Here is a Valve that will give you COMPLETE service on water mains, turbine pump discharge, bowls of booster pumps, air tanks, sand traps – in fact, wherever you require COMPLETE CONTROL of air inlet, discharge, or of air and water levels.

It has the simplicity and reliability you will find in all Rensselaer products. It will not blow shut under high velocity air discharge. It closes positively under low water head. It has full clear passage for air, reducing friction to minimum. All internal working parts are solid bronze. Special air release rubber valve has long life, is tight-seating. Complete details on request.

Do you want to know more about this triple-service Valve, or any of the many other Rensselaer products? Send for our Representative. There is one near you, ready to serve without obligation on your part. Call him today.

LEADERSHIP FOR OVER 65 YEARS

RENSSELAER

Gate Valves • Square Bottom Valves • Tapping Valves and Sleeves
Hydrants • Check Valves • Air Release Valves

RENSSELAER VALVE COMPANY • TROY, N. Y.

Division of Neptune Meter Company

Atlanta, Bala-Cynwyd, Pa., Chicago, Denver, Haverhill, Mass., Hornell, N. Y., Kansas City, Los Angeles, Memphis, Oklahoma City, Pittsburgh, San Francisco, Seattle, Waco

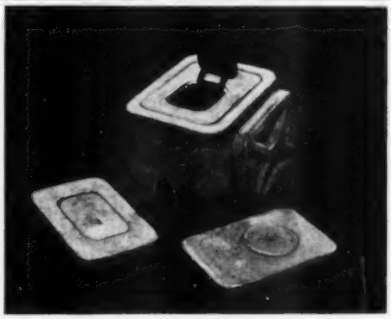
(*Continued from page 8*)

A "Valve Manual for Water Works and Sewage Works Operators" has been issued as the combined April & July 1949 issues of the *Journal of the Missouri Water and Sewerage Conference.* Compiled by Vance Lischer, consultant of Horner & Shifrin, with the cooperation of valve manufacturers, the 76-page booklet contains generously illustrated descriptions of various types of valves, sections on selection, maintenance, and methods and devices for valve operation are included. Copies of the manual may be obtained from the Secretary-Treasurer, Missouri Water and Sewerage Conference, State Office Bldg., Jefferson City, Mo., at a cost of $2.50 each.

A stream survey in the Rondout-Wallkill basin inaugurates the first such campaign to be undertaken by the recently created Water Pollution Control Board of New York. The investigating team included two sanitary engineers, two chemists and an aquatic biologist. Cooperating with the board and the State Health Dept. in the venture are local health officials and the U.S. Public Health Service, which has loaned a mobile laboratory. It is expected that this first, experimental study on a typical watershed will help establish operating procedures and provide experience for survey personnel.

(*Continued on page 12*)

CARSON CLAMPS
Stop Joint Leakage
Write for information
CARSON-CADILLAC COMPANY
1221 Pinson Street
Birmingham, Alabama



3,000,000 ART CONCRETE METER BOXES NOW IN USE!

Since 1911 more than 1,500 different water systems throughout the Pacific Coast and Southern states have installed Art Concrete Meter Boxes!

Let us explain how you, too, can benefit from Art Concrete. Write!

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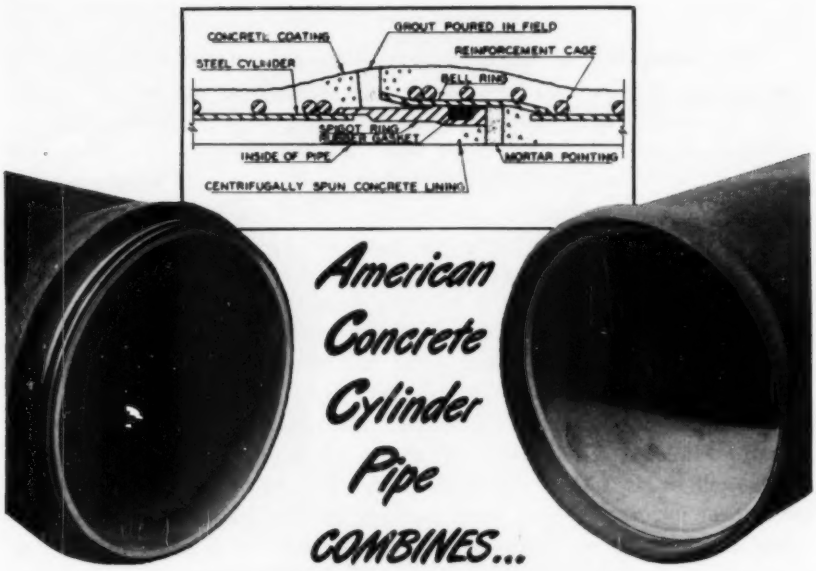

American Concrete Cylinder Pipe COMBINES...

√ The physical strength and characteristics of steel

√ The positive protection and permanency of concrete, inside and out

√ The simplicity, flexibility and safety of Lock Joint Rubber Gasket Joints

. . . TO REDUCE THE COST OF DELIVERED WATER

Although the Company began the development and manufacture of this pipe eighteen years ago, 1941 marks the first appearance of this composite, modified pre-stressed pipe in its present form. Since that time, it has become established throughout the West as one of the outstanding developments in the field of pressure transmission of water. American Concrete Cylinder Pipe combines greatest efficiency and economy in the medium diameter range from 14″ to 36″ inclusive and in the range of operating pressures from 100 psi upward. This pipe is manufactured in nominal lengths of 30 feet. Its design incorporates the physical properties of steel with the protection and permanency of concrete. The Lock Joint Rubber Gasket Joint simplifies installation—assures positive water-tightness under normal operating conditions.

The economies of American Concrete Cylinder Pipe are reflected in initial cost, ease of installation, sustained capacity, and trouble-free service. All of these factors mean substantial savings in the cost of delivered water. Complete information is available upon request.

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Concrete Pipe for Main Water Supply Lines, Storm & Sanitary Sewers, Subaqueous Pipe Lines

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Main Offices and Plant—4635 Firestone Blvd., South Gate, Calif.
District Sales Offices and Plants—Oakland, San Diego, Portland, Oregon

(*Continued from page 10*)

The versatility of water is one of its characteristics we take for granted until it is pointed up by some such situation as has existed on the island of Madeira almost from the beginning of time. Ever since 1493, as a matter of fact, Madeirans have been devising projects to overcome a serious water shortage by diverting the abundant supply of the mountainous northern regions to the inhabited southern part of the island. Madeira being what it is, Madeirans have not, of course, suffered a 450-year thirst, but since no one yet has figured out how to harness the power of wine for generating electricity or how to make it palatable to plants, Madeira itself has been practically powerless as well as unirriguous.* News that the Portuguese government has instituted a large program of hydroelectric and irrigation development, to be completed in 1951, thus heralds the end of an ancient problem. But more than that, consider the boon to Madeiran civilization. With an adequate supply of *agua,* Madeirans will at last have a chance to change their beverage, to take full advantage of inside plumbing, even perhaps to take bubble baths in something less sticky than champagne. It's possible, of course, that we've misimagined the present status of Madeira, but no matter, the versatility of water is still worth a think or two.

Speaking of baths, though, reminds us to give you notice that next month will be the 107th anniversary of Adam Thompson's pioneering plunge in Cincinnati—the first bathtub bath of American history. And if you don't think that that immersion evoked even more publicity than some of the more artistic dips by our current Hollywood Eves, you don't read the *Wall Street Journal.* Just what effect Adam's aquation had upon the

* If you prefer, irrigatedlessness or irrigatednessless, perhaps even unirrigatedness, but we and Webster prefer our term as denoting better the rigors of irrigationwaterlessness.

(*Continued on page 14*)

Cathodic PROTECTION is More Than Equipment

You can purchase good cathodic protection *equipment* from many reputable manufacturers of anodes, rectifiers, etc. But that's only half the answer to rust and corrosion problems. The rest of it is technical skill in the *application* of cathodic protection equipment and theory.

Electro Rust-Proofing has, at your disposal, a trained staff of corrosion specialists ready to give each problem the individual attention required for successful solution. Why not write today? There's no obligation.

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BELLEVILLE 9, NEW JERSEY
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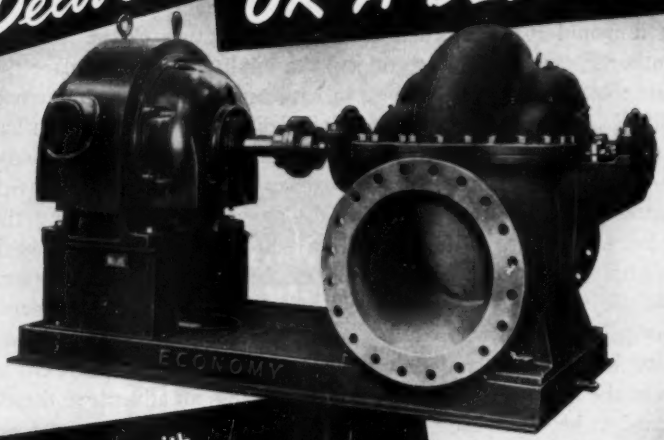
Deliver a drop... OR A DELUGE!



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DOUBLE SUCTION PUMPS

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Economy Double Suction Pumps meet your needs . . . for most any volume. More than 1500 models designed for every type drive assure you the right pump for your requirements . . . with these advantages:

1. Complete rotor may be removed without exposing bearings which are enclosed in removable cartridges.
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5. All parts made to limit gauges for interchangeability.
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7. No threads in center of shaft to start fatigue failure.
8. Large wells for lubrication with flushout for old lubricant.

For full details write Dept. AG-11 for Catalog 1147A.
Centrifugal, axial and mixed flow pumps for all applications.

Economy Pumps Inc.

DIVISION OF HAMILTON THOMAS CORP. HAMILTON, OHIO

(Continued from page 12)

stock market we aren't yet sure, but it is to its journal that we owe our information.

Not from water works men or perfume peddlers, who may have had some legitimate cause for concern, did the protests come, however. It was first the medical profession which decried the "pernicious" practice, claiming that it would result in rheumatism, inflammation of the lungs and a host of other ailments which would sap the vitality of the populace. Then politicians took up the cause, seeing in bathing "the end of our democratic way of life." Even action followed: Philadelphia attempted to ban bathing from the first of November to the first of March; Boston prohibited the practice except upon advice of a physician; and Hartford, Providence, Wilmington and other cities tried to distub people by assessing them a prohibitive water tax. Finally, even a state took the matter in hand, Virginia imposing a tax of $30 a year upon every bathtub in the state.

That this antipathy has since disappeared is reflected in the facts that, of the normal domestic water bill, approximately 30 per cent represents charge for bath water; and that we still remember the Saturday night polemics in the family circle. And if a bath is less an adventure these days than it used to be, there are perhaps compensations. At any rate, we, for one, will be happy to be able to celebrate this Adam's anniversary with at least a pre-Christmas tubbing in a water that's both soft and safe.

The first Chief Basin Engineer for the North Atlantic Drainage Basin, Kenneth C. Lauster, was appointed as the implementation of the Water Pollution Control Act of 1948 gathered momentum. The basin, with headquarters in New York City, is a field operation of the Water Pollution Control Div. of the U.S. Public Health Service, and is one of ten into which the country is divided. Ultimately, 14 river basin areas will be established. A registered professional engineer, Lauster has been executive officer of the Water Pollution Control Advisory Board in Washington. Previously he had been chief engineer of the North Dakota Div. of Sanitary Engineering.

P. S. Wilson of Glen Ridge, N.J., has joined the staff of Energy Control Co. as a specialist on water works metering and control equipment. An item recently added to the list of instruments handled by the company is the Bethlehem Flow Tube, which it is claimed offers measurement of flow with a minimum pressure loss and low first cost.

Francis S. Friel, consulting engineer of Albright & Friel, who recently was awarded an honorary Doctor of Engineering degree by Drexel Inst. of Technology (P&R August 1949, p. 8), has just been appointed to the board of trustees of that institution.

(Continued on page 16)

ACCURATE • SAFE • SIMPLE • DEPENDABLE • ATTRACTIVE

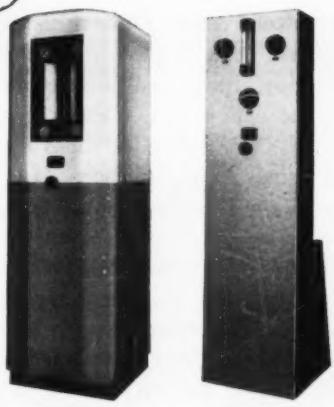
BUILDERS *Chlorinizers*

CHLORINE GAS FEEDERS

VOLUMETRIC — SOLUTION FEED
VACUUM TYPE

Builders Chlorinizers are thoroughly field tested products of Builders-Providence, Inc., a company that has specialized in equipment for metering and controlling flow for more than fifty-five years, and with whom excellence in design and manufacture has been a tradition since 1820.

For full information and descriptive bulletins, address Builders-Providence, Inc. (Division of Builders Iron Foundry), Providence 1, R. I.



MODEL CVS MODEL DVS

BUILDERS—PROVIDENCE
Instruments

(*Continued from page 14*)

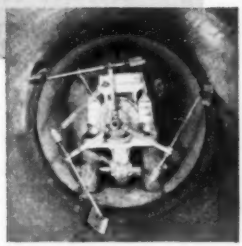
Having eschewed supernaturalism in favor of science, we can now report real progress in the science of dowsing. So what if Jabbo Smith, a twig-twitching tenant on Jim Threadgill's farm near Paris, Tex., discovered a 22-ft. deep supply only 50 yards away from where oil prospectors had sunk 340-ft. and 570-ft. holes in a vain search for water—we're much more impressed with a development by Dr. Albert W. Hull, Asst. Director, General Electric Research Lab., of an improved "magnetometer." Patently (and Dr. Hull's new device is patented), an instrument consisting of a detecting coil, which produces a current proportional to the strength of the earth's magnetic field, and equipment for measuring variations in the current so produced, all gyroscopically aligned with the earth's field, must be more trustworthy than a peach twig. For the present, of course, Dr. Hull's improved magnetometer will not be made commercially available, not necessarily because its cost would be slightly greater than Jabbo's $25 charge for finding and unearthing a water supply, but because the need for such an instrument, applicable to the hunting of sunken ships and the aircraft surveying of vast areas for iron deposits, is to date "extremely limited." Understanding that the magnetometer is sensitive to slight variations in the earth's magnetic field, such as those caused by iron deposits in the ground, however, we look forward to the early realization that it can readily be applied to the detection of underground iron-bearing waters. And then where will Jabbo and his peach twig be?

A pattern making instrument claimed to eliminate hours of tedious drafting has been created to solve most of the problems encountered in welding pipe fittings and in sheet metal work. Called the SMW Pattern Maker, the device is a modified parallel-leg compass with an adjustable radius bar. The scribe-leg slides in a bearing on the radius bar to project desired shapes on any surface. It is available from E. A. Scott, publisher of *Sheet Metal Worker,* 45 W. 45 St., New York, for $7.50.

An upbubblement unparalleled left Charlotte, N.C., with the cleanest street this side of heaven last month, and, strangely enough, neither the water nor the street cleaning department had a hand in the supersanitation. First cause, as a matter of fact, was a series of bumps which tumbled a drum of liquid shampoo from a passing truck. Accessory after the mess was the fire department which appeared shortly to wet down the slippery pavement. And then onto the scene rushed the police department to reroute traffic around the bubble-blocked thoroughfare. Actually it was a full two hours before the 9-ft. geyser of gutter-born globules could be dispelled and the street again opened to traffic—without dandruff, but still damnedrough.

(*Continued on page 18*)

where performance counts . . . count on Centriline



In Cincinnati's program to recondition its water mains for greater efficiency and economy, Centriline has recently completed its fifth contract since 1940.

A total of more than 68,000 feet of cast iron pipe has been cleaned and uniformly lined with dense cement mortar in this city. Pipe sizes were from 24" to 48". On the last job, the average speed of lining was better than 1,000 feet per day—resulting in minimum interruption in water distribution.

Cincinnati has found that Centrilining pays. It will establish and maintain a high coefficient, reduce pumping cost, stop all leakage and terminate deterioration. Consult Centriline's experienced hydraulic engineers. A 28-page illustrated bulletin is also available on request.

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142 CEDAR STREET

NEW YORK 6, N. Y.

CEMENT MORTAR LININGS FOR WATER MAINS CENTRIFUGALLY APPLIED in strict conformity with A. W. W. A. Specifications.

(Continued from page 16)

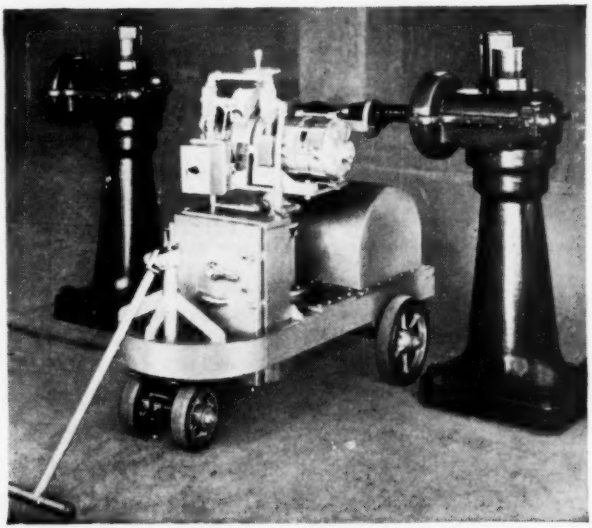
"IF I had a million dollars" may have been an all too accurate introduction to last month's tale of windfall at Perryopolis, Pa. (see October P&R p. 10). At any rate, that million-plus dollar legacy, the spending of which took Perryopolitans more than a year to plan, threatens now to vanish into thin air, or heirs, with the eleventh-hour agreement by no less than six first cousins of benefactress Mary Fuller Frazier that she could not have been of "sound mind" in willing that much of her $2,085,000 estate out of the family. Thus, that water and sewage plant and all the other civic improvements blueprinted may never materialize and Perryopolis' painstaking planning may turn out to be merely an exercise in illusion.

Appropriately enough it was in Orphans Court, Philadelphia, that the cousinry petitioned to deprive Perryopolis of its town mother, and now it will remain for the courts to decide whether she can really remain a mother-in-law. Meanwhile, we ponder a new application of the old saw that says blood is thicker than water (or, perhaps, sewage).

James A. Snook Jr., Rusta Restor representative in California, Nevada and Arizona for the past ten years, wishes to add additional lines. His office is at 967 Russ Bldg., San Francisco 4, Calif.

(Continued on page 20)

LIMITORQUE "*PORTABLE*" VALVE OPERATOR



New . . . the well-known, widely used *"Limitorque"* Motorized Valve Operator, in *Portable form* . . . for use wherever a hand-drawn truck CAN BE WHEELED TO Valve or Sluice Gate location May be quickly connected to power outlet . . . and automatic *electric opening and closing is readily secured.*

Portable "LimiTorque" is equipped with famous *torque-limiting feature* (operates in Opening and Closing directions); *Limit switch* may be set for any travel (automatic resetting); *Universal Joint* connection for compensation of misalignment between floorstand and power unit.

This unique electrical valve operation is *another first* for Philadelphia. It embodies the salient and proven features that have made *"LimiTorque" Valve Operators* the most widely used in the world.

PHILADELPHIA GEAR WORKS, INC.
ERIE AVE. AND G STREET **PHILADELPHIA 34, PA.**
Manufacturers of Industrial Gears, Speed Reducers, LimiTorque Valve Controls
NEW YORK . HOUSTON . PITTSBURGH . CHICAGO

Send for 96 page "Limitorque" Catalog and please use your Business Letterhead when requesting same.

FROST-PROOF CALMETS
operate efficiently in all climates

The *frost-proof bolt* plus *the split case design* of CALMET Water Meters provides effective and economical protection against damage from freezing or excessive pressure. The combination of these two features in one meter eliminates carrying large stocks of parts to service several types of meters. Standardize *today* on CALMET, the meter of *tomorrow*, for long-lasting, trouble-free metering in all climates!

• SALES REPRESENTATIVES—*Write for complete details of the CALMET franchise in your territory.*

CALMET WATER METERS

MADE BY WELL MACHINERY & SUPPLY CO., INC.—FORT WORTH, TEXAS

(*Continued from page 18*)

Literal to a fault is one Martin Kohn of Rock Island, Ill. Only last month, according to *Time* magazine, they caught him riding on the town water wagon, drunk. And if his apprehension gets him "down in the dumps," they'll at least know where to look for him.

The California Municipal Utilities Assn. is meeting Nov. 16–18 at the Hotel Casa del Rey, Santa Cruz. Papers will be given on such problems of general interest as economic conditions, the testing of drivers and the handling of traffic while street excavation is in process.

An atomizing valve suitable for use in vacuum deaerators and hot process softeners is offered by Belco Industrial Equipment Div. in capacities up to 2,000 gpm. The valve is a non-clogging, proportioning type, and produces a tangential spraying action, atomizing incoming water to droplet form.

A new warehouse at 1611 Dragon St., Dallas, Tex., has been opened by Chain Belt Co. to serve its Dallas District sales office. The office facilities also are being expanded.

(*Continued on page 22*)

3 *Money, Time and Labor Saving Features of*

UNIVERSAL* CAST IRON PIPE

LAID WITH ONLY WRENCHES →

NO CAULKING MATERIALS →

NO GASKETS. NO BELL HOLES TO DIG. →

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For water supply, fire protection systems, sewage disposal systems, industrial, and irrigation. Flexible.

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Prompt notification will keep your Journals and other communications coming to you without annoying delays and lapses.

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For dependable 8-minute softening use the streamlined Permutit® Spiractor®

Permutit has added new speed to lime treatment. The Spiractor softens water twenty times faster than old style methods and takes up far less space!

FAST but SURE!

The Spiractor is sturdy and dependable, operates simply, and requires a minimum of maintenance. Raw water mixed with lime enters at the base of the cone at a velocity high enough to suspend a catalyst bed of calcium carbonate granules, low enough to avoid carry-over. The water softening reaction results in precipitates that are deposited on these granules by accretion. Enlarged granules are drawn off through valve in base—and disposed of as easily as moist sand grains. No messy sludge to get rid of!

The softened water, clear and low in alkalinity, is ready for suitable filtration.

Write for details to The Permutit Company, Dept. JA-11, 330 West 42nd Street, New York 18, N. Y., or to The Permutit Company of Canada, Ltd., Montreal.

Permutit

For over 35 Years Water Conditioning Headquarters

(*Continued from page 20*)

Alfonso Villa-Acosta, consulting sanitary engineer with the Ministry of Hydraulic Resources at Mexico City, passed away on July 30, after a short illness resulting from a heart attack. A short time previously he had been well enough to act as host to American water works engineers attending the A.S.C.E. convention, and news of his death came as an unexpected shock.

Heber K. Burton, retired superintendent of the Salt Lake City water department, died at the age of 78 on September 14, after a lingering illness.

George M. Robbins, Minneapolis representative for U.S. Pipe and Foundry Co., died on September 6. A memorial resolution in his honor was adopted by the Minnesota Section at its annual business meeting on September 9, and a copy sent to his family.

Warren Foundry & Pipe Corp. has moved its New York office on October 24 from 11 Broadway to 55 Liberty St. to provide more office space. The new phone number is WOrth 4–7993.

NEW HELLIGE COLOR DISC FLUORIDE

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NON-FADING
GLASS COLOR
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SPARLING
Main-Line Meters

Consistent Accuracy
Ease of Installation
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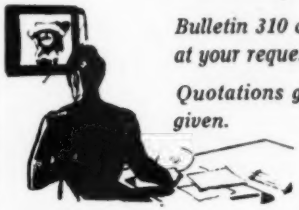
Low Pressure Loss



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Take advantage of our large stock of non-standard patterns when in need of special castings to meet your individual requirements.
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Membership Changes

NEW MEMBERS

Applications received September 1 to 30, 1949

Allen, E. L., Sr., Water Production Supt., Utilities Com., 411 E. Amelia Ave., Orlando, Fla. (Oct. '49)

Allen, Wharton Harwell, Sales Engr., Evans L. Shuff & Assoc., Box 1295, Nashville 2, Tenn. (July '49) *MP*

Anckaitis, Victor William, City Engr., Bureau of Water, City Hall, Easton, Pa. (Oct. '49) *M*

Basich, George O., Repr., Rensselaer Valve Co., 1737 S. 81st St., West Allis, Wis. (Oct. '49) *M*

Bennett, A. L., Public Health Engr., State Health Dept., Dist. Health Service No. 7, Washington, Iowa (Oct. '49)

Berigtold, Charles N., Jr. Assoc. Engr., Bureau of Water Supply, 8 W. 2nd Ave., Baltimore 25, Md. (Oct. '49) *M*

Book, C. Edgar, *see* State College Borough Authority

Bostwick, T. W., Plants Efficiency Engr., Elec. & Water Utilities Dept., Utilities Bldg., S. Laura St., Jacksonville 2, Fla. (Oct. '49)

Callery, Currie T., Water Plant Operator, Water System, Brownsville, Tenn. (Oct. '49) *M*

Christopher, Grigsby S., San. Engr., Tennessee Valley Authority, 1231 Greer Circle, Sheffield, Ala. (Oct. '49)

Conrady, Elmo, Supt., Water Dept., S. Cherry St., Mt. Carmel, Ill. (Oct. '49)

Conway, Hollis R., Prin. San. Engr., Bureau of San. Eng., State Board of Health, Little Rock, Ark. (July '49)

Crippen, Huston D., Eastern Mgr., *Water & Sewage Works,* Gillette Publishing Co., 155 E. 44th St., New York 17, N.Y. (Oct. '49)

Crouse, John William, San. Engr., State Board of Health, Little Rock, Ark. (July '49) *MP*

Davison, Robert W., Water Plant Supervisor, 709 Cleveland St., Watertown, N.Y. (Oct. '49) *P*

Decot, Valentine F., Gibney-Coffman Co., 17 Lincoln Rd., Buffalo 21, N.Y. (Oct. '49)

Drake, Hal M., San. Engr., State Board of Health, 3620 W. 12th St., Little Rock, Ark. (July '49) *P*

Eckler, Clyde I., Supt., Water Dept., 201 S. Leroy St., Fenton, Mich. (Oct. '49) *M*

Edgerley, Edward, Dist. Engr., Bureau of San. Eng., State Dept. of Health, 343 N. West End Ave., Lancaster, Pa. (Oct. '49) *P*

Elliot, Simon F., Co-owner, Blackburn Eng. Co., 111 E. 5th St., Pueblo, Colo. (Oct. '49) *MPR*

Ellis, Joseph E., Jr., Sales Engr., Ellis & Lowe Co., 3710 Platt St., Tampa 6, Fla. (Oct. '49)

Estrada, Alfred A., Prin. Engr., Albright & Friel, Inc., 121 S. Broad St., Philadelphia 7, Pa. (Oct. '49) *P*

Evans, Stanley W., Dist. Supt., Northern Indiana Public Service Co., 107 W. Center St., Warsaw, Ind. (Oct. '49) *MP*

Federspiel, Theron R., Salesman, Ulrich Chemical Co., 31 E. Georgia St., Indianapolis, Ind. (Oct. '49) *P*

Fletcher, Fred, Chief, Water Works Section, State Health Dept., 130 Delta St., Mt. Joy, Pa. (Oct. '49) *P*

Fort Scott Water Dept., Hilton H. Wogan, Comr. of Streets & Public Utilities, Fort Scott, Kan. (Corp. M. Oct. '49)

Gable, Tom S., Director, Food & Sanitation, City Health Dept., 702 W. 6th Ave., Flint, Mich. (Oct. '49) *P*

Gibney, William J., Gibney-Coffman Co., 17 Lincoln Rd., Buffalo 21, N.Y. (Oct. '49)

(*Continued on page 30*)

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(*Continued from page 28*)

Glenz, K. A., Asst. Div. Mgr., Municipal Management Co., 253 W. 4th St., Williamsport, Pa. (Oct. '49) *M*

Grant, Walter Schuyler, Jr., Chief Engr., Water Works Com., Newport News, Va. (Oct. '49) *M*

Gray, A. C., Owner, Gray Well & Pump Co., 904 Garfield St., Jacksonville, Fla. (Oct. '49)

Hageman, F. M., *see* Portland, City of

Halladay, L. L., Plant Engr., Water Works, 229 City Hall, Minneapolis, Minn. (July '49)

Hastings, H. K., Repr., Stifel, Nicolaus & Co., Inc., 433 Hawley Bldg., Wheeling, W.Va. (Oct. '49)

Haws, Ray C., San. Engr., State Board of Health, Little Rock, Ark. (July '49) *MPR*

Healy, Edward R., Supervising Engr., Illinois Water Service Co., 122 N. Walnut St., Champaign, Ill. (Oct. '49) *M*

Hendrickson, Clyde, *see* Indiana Boys School

Hennigan, Robert D., Asst. Dist. San. Engr., State Dept. of Health, 411 Herald Bldg., Syracuse, N.Y. (Oct. '49)

Honolulu Suburban Water System, Phillip K. H. Yee, Acting Engr. & Supt., 405 City Hall, Honolulu, Hawaii (Corp. M. Oct. '49) *MPR*

Hopper, Samuel H., *see* Indiana University School of Medicine

Howson, J. T., Supt. of Water, 116 Elm St., Westfield, N.Y. (Oct. '49) *M*

Indiana Boys School, Clyde Hendrickson, Chief Engr., Plainfield, Ind. (Corp. M. Oct. '49) *MPR*

Indiana University School of Medicine, Dept. of Public Health, Samuel H. Hopper, Assoc. Prof. of Public Health, 1040 W. Michigan St., Indianapolis 7, Ind. (Corp. M. Oct. '49) *P*

Jacobs, Herbert A., City Supt., Montague, Mich. (Oct. '49) *M*

Jones, D. W., Supt., Public Works, North Miami, Fla. (Oct. '49)

Kaplan, Ray, Asst. Chemist-Bacteriologist, Water Dept., 216 Court House, St. Paul 2, Minn. (Oct. '49) *M*

Keever, Blaine, Supt., Water Dept., Cody, Wyo. (Oct. '49) *MP*

Kellogg, Glen T., Prin. San. Engr., State Health Dept., Little Rock, Ark. (July '49) *P*

Lanouette, Kenneth H., Jr. Sales Engr., The Dorr Co., 1009—17th St., Denver, Colo. (Jr. M. Oct. '49)

Lindlief, Elwin, City Clerk, Storm Lake, Iowa (July '49) *M*

Lipscomb, Joseph William, Asst. San. Engr., State Dept. of Health, Richmond, Va. (Oct. '49) *P*

Logansport, City of, Robert E. Price, Supt. of Utilities, Logansport, Ind. (Corp. M. Oct. '49) *MP*

Mapp, C. H., Supt. of Utilities, 312—4th St., Forest, Miss. (Oct. '49)

Martin, N. V., Gen. Mgr., The Bournemouth Gas & Water Co., Alderney Water Works, Kinson, Bournemouth, Hants., England (Oct. '49)

Massey, G. Hubard, Cons. Engr., Fairfax, Va. (Oct. '49)

Mathews, W. C., Engr., Box 116, Tupelo, Miss. (Oct. '49)

Maury, Richard L., Director, Public Works, Box 1112, Martinsville, Va. (Oct. '49)

Mayeron, Harry, G. M. Orr Eng. Co., 1004 Marquette Ave., Minneapolis, Minn. (Oct. '49)

McGoodwin, Lionell Maxwell, Cons. Engr., Sullivan & McGoodwin, Goshen Rd., Fayetteville, Ark. (Oct. '49)

McMahon, Frank J., Supt., Municipal Water, Light & Power Plants, 127 Broadway, Lowell, Mich. (Oct. '49) *R*

Medlicott, Arthur M., Water Works. Mechanic & Electrician, Water Dept, 326 N. 19th St., Fargo, N.D. (Oct. '49) *MP*

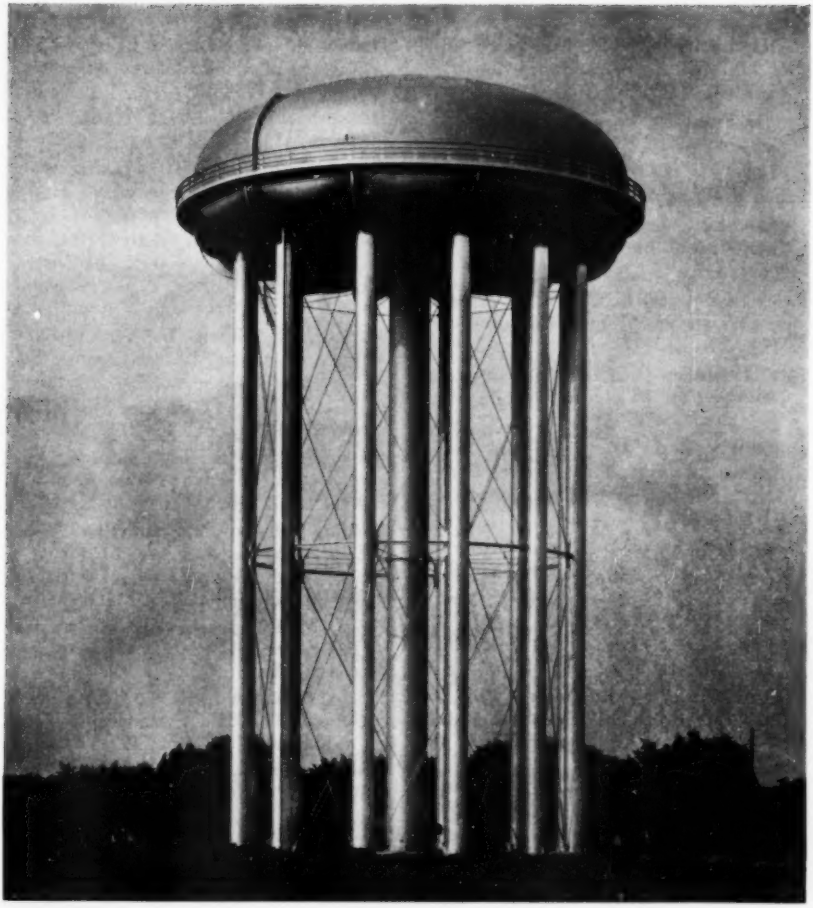
Mitchell, Charles B., Munic. Engr., Michael Baker Jr., Inc., 115 Shields St., Rochester, Pa. (Oct. '49) *M*

Morgan, Edward J., Mgr., Water Sales Div., Board of Water Supply, Honolulu, Hawaii (Oct. '49) *M*

Myers, Joseph Francis, Assoc. Engr., Water Div., Dist. of Columbia Govt., Dist. Bldg., 14th & E Sts., N.W., Washington, D.C. (Oct. '49)

Pitkin, William V., Salesman, Ulrich Chemical Co., 31 E. Georgia St., Indianapolis, Ind. (Oct. '49) *P*

(*Continued on page 32*)



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(*Continued from page 30*)

Portland, City of, F. M. Hageman, Supt. of Utilities, Portland, Ind. (Corp. M. Oct. '49) *MP*

Prager, Frank D., Mfrs. Consultant, Puromat Co., 53 E. Van Buren, Chicago 5, Ill. (Oct. '49) *P*

Price, Robert E., *see* Logansport, City of

Quattlebaum, Cephas P., Assoc. Engr., Quattlebaum Eng. Co., Johnston, S.C. (Oct. '49)

Reichstein, Amiel A., City Engr. & Supt., City Water Works, Fairfield, Iowa (Oct. '49)

Rice, Lawrence G., Cons. San. Engr., 11 Country Club Pl., Camp Hill, Pa. (Oct. '49) *MPR*

Rutherford, Kyle W., Asst. San. Engr., Bureau of San. Eng., State Health Dept., 22 N. 9th St., Richmond, Va. (Oct. '49) *P*

Sharp, T. A., *see* Tipton Water Utility

Sheldrake, G. Edwards, Filter Plant Supervisor, Dept. of Public Works, Bureau of Water, Queen Lane Filter Plant, Queen Lane & Fox St., Philadelphia 29, Pa. (Oct. '49)

Siegel, Joseph, Civ. Eng. Assoc., Dept. of Water & Power, Box 3669 Terminal Annex, Los Angeles 54, Calif. (July '49)

Simpson, Leslie, Supt., Munic. Elec Light & Water, 203 E. Adrian St., Blissfield, Mich. (Oct. '49) *MPR*

Smart, Roy Louis, Jr., Dist. Sales Mgr., Mathieson Chemical Corp., Box 264, Jacksonville, Fla. (Oct. '49) *P*

Spencer, Walter, Supt., Merchantville-Pennsauken Water Com., 13 W. Maple Ave., Merchantville, N.J. (Oct. '49)

State College Borough Authority, C. Edgar Book, Secy.-Treas., 118 S. Frazier St., State College, Pa. (Corp. M. Oct. '49)

Stimpson, Kenneth L., Sales Mgr., Utilities Com., Orlando, Fla. (Oct. '49)

Stoutenburgh, James H., Water Well Contractor, Glenford, N.Y. (Oct. '49)

Sumner, Billy Taylor, Resident Engr., Polk, Powell & Hendon, Engrs., 404 Cotton States Bldg., Nashville 3, Tenn. (July '49) *MPR*

Tauber, Edward J., Sales Engr., Byron Jackson Co., 808 Graybar Bldg., New York, N.Y. (Oct. '49)

Teunisson, John Henry, Jr., City Engr. & Director of Public Works, Greenville, Miss. (Oct. '49) *MP*

Thompson, F. E., Supt., Water Dept., Macon, Miss. (Oct. '49)

Tipton Water Utility, T. A. Sharp, Water Utility Supt., 225 E. Jefferson, Tipton, Ind. (Corp. M. Oct. '49) *M*

Ward, Raymond B., Water Registrar, Dist. of Columbia Govt., 16 District Bldg., 14th & E Sts., N.W., Washington, D.C. (Oct. '49)

Warrington, William G., Acting Supt., Bureau of Water, 29th & Cambria Sts., Philadelphia, Pa. (Oct. '49) *M*

Waterstraut, Lloyd Carl, City Mgr., Three Rivers, Mich. (Oct. '49) *MP*

Weber, Roy E., San. Engr., George Brockway, Cons. Engrs., 404 Guaranty Bldg., West Palm Beach, Fla. (July '49) *P*

Weight, William King, San. Eng. Assoc., Dept. of Water & Power, 1028 Municipal Water & Power Bldg., 316 W. 2nd St., Los Angeles, Calif. (Oct. '49) *PR*

Wells, Monroe, San. Engr., U.S. Army Post Engrs., 3160 Mountain View, Sacramento, Calif. (Oct. '49)

Wilcox, Cranston J., Public Health Engr., Branch—Hillsdale Dist. Health Dept., Coldwater, Mich. (Oct. '49)

Wilkens, Henry, Jr., Dist. Mgr., Texas Water Co., Box 11038, Houston 16, Tex. (Oct. '49) *MR*

Williford, Howard Kent, Asst. Prof., Dept. of Civ. Eng., Mississippi State College, State College, Miss. (Oct. '49) *MP*

Wing, Walter E., Operator, Ypsilanti Township Water Works, 20751 Martinsville Rd., Belleville, Mich. (Oct. '49)

Wise, Clyde, Water Supt., Jacksonville Water Co., Jacksonville, Ark. (July '49)

Wogan, Hilton H., *see* Fort Scott Water Dept.

Yee, Phillip K. H., *see* Honolulu Suburban Water System

REINSTATEMENTS

Abercrombie, J. S., Co., C. W. Shively, 2105 Gulf Bldg., Houston 2, Tex. (Corp. M. Jan. '40)

Montank, Irwin A., Sr. Chemist & Bacteriologist, Softening Plant, Water Dept., 43rd & Marshall Sts., N.E., Minneapolis, Minn. (Jan. '28) *P*

(*Continued on page 34*)

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(Continued from page 32)

Olson, W. M., 436 Normal Pkwy., Chicago 21, Ill. (Apr. '26)

Shively, C. W., *see* Abercrombie, J. S., Co.

LOSSES

Deaths

Bond, Philip E., Owner, Tighe & Bond, Cons. Engrs., 189 High St., Holyoke, Mass. (Jan. '48)

Des Baillets, C. J., Chief Engr., Eng. Div., 3161 Joseph St., Verdun, Que. (Mar. '34) *Fuller Award '45. P*

Fales, Almon L., Cons. Engr., Metcalf & Eddy, Cons. Engrs., 1300 Statler Bldg., Boston 16, Mass. (Feb. '21) *P*

McDonough, Frank J., Asst. Mech. Engr., City of Chicago, Dept. of Public Works, 811 N. Michigan Ave., Chicago 11, Ill. (Oct. '41) *M*

Olsen, Fred J., Supt., Palatine Hill Water Dist., 255 S. W. Breyman St., Portland 1, Ore. (Apr. '40)

O'Reilly, Thomas C., Asst. Civ. Engr., Water Dept., 215 W. Broadway, Long Beach, Calif. (Oct. '46) *M*

Osborne, James Q., Dist. Mgr., DeLaval Steam Turbine Co., 706—3rd Ave., Seattle 4, Wash. (Jan. '28)

Robbins, George M., Sales Agent, U.S. Pipe & Foundry Co., 625 Plymouth Bldg., Minneapolis 2, Minn. (Oct. '39)

Villa-Acosta, Alfonso, Cons. San. Engr., Ministry of Hydr. Resources, Mier y Pesado 222, Mexico, D. F., Mexico (Apr. '30) *PR*

Warde, John S., 7 Whitewood Ave., West Brighton, S. I. 10, N.Y. (May '30)

CHANGES IN ADDRESS

Changes received between September 5 and October 5, 1949

Alderman, Frank E., Cons. Engr., 203 Rialto Theatre Bldg., South Pasadena, Calif. (Oct. '39) *MPR*

Anderegg, James A., 7 Clarendon Ave., Montpelier, Vt. (Jan. '49)

Applebaum, Samuel B., Hotel Sheraton, Rittenhouse Sq., Philadelphia 3, Pa. (Apr. '16) *P*

Arbuthnot, James B., Regional Consultant, World Health Organization, Box 1517, Alexandria, Egypt (Oct. '46) *P*

Arnold, William L., Public Accountant, 126 N. Florance, Monterey Park, Calif. (July '33)

Baker, Roger C., 301 Porbeck Bldg., Little Rock, Ark. (Apr. '47) *R*

Bastian, Edward D., 49 Berwyn Pl., Bergenfield, N.J. (Jan. '48) *P*

Bethencourt, Daniel, O No. 201, Vedado, Havana, Cuba (Jan. '49)

Blankenship, Reginald L., Contractor, Public Works, Blankenship & Carneal, 3310 Forest Hill Ave., Richmond, Va. (July '40)

Cary, Edmund Shepard, Asst. San. Engr., State Dept. of Public Health, 836 S St., Fresno, Calif. (July '49)

Casco, A. Andres, Oficina SCISP, Tequicigalpa, D.C., Honduras (Jr. M. Jan. '49)

Chatterjee, S., 28 Behary Chakraburtty Lane, Howrah, West Bengal, India (Apr. '49)

Culp, Russell L., 1740 Vermont St., Lawrence, Kan. (July '48)

Denize, Clement F., 17 Ave. Ducoste, Port au Prince, Haiti (July '49) *MP*

Dowlin, M. R., 5831 S. Lawrence, Tacoma 9, Wash. (Jan. '44) *P*

Dwelle, Ralph H., 313—5th St., Riverdale, N.D. (Jan. '46)

Eldridge, Edward F., Pollution Control Com., Olympia, Wash. (Oct. '46) *P*

Evans, Charles H., Chicago Branch Sales Mgr., Rensselaer Valve Co., 4048 W. Taylor, Chicago 24, Ill. (July '47)

Frazier, Irvin, Hays Mfg. Co., 1940 S. Cotner Blvd., Lincoln, Neb. (July '44) *M*

Fromherz, Frank C., Fromherz Engrs., 823½ Poydras St., New Orleans 13, La. (Jan. '48)

Glassel, O. E., Industrial Engr., The Foxboro Co., 15770 Wyoming Ave., Detroit 21, Mich. (Apr. '48)

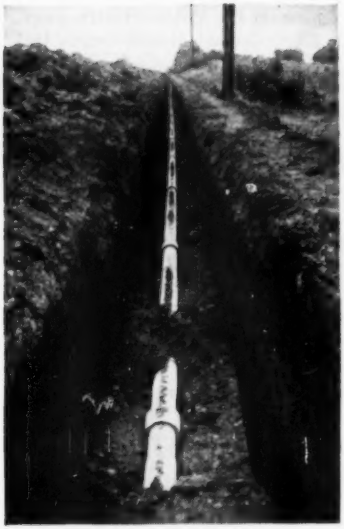
Graver Water Conditioning Co., Henry T. Sulcer, Gen. Mgr., 216 W. 14th St., New York 11, N.Y. (Assoc. M. June '30)

Hansen, Robert E., Supt., Filtration Plant & Pumping Station, R.F.D. 8, Box 194, Mt. Clemens, Mich. (Jan. '47) *P*

Hanson, Arthur M., 1150 Western Ave., Albany, N.Y. (Oct. '43) *P*

(Continued on page 36)

K&M "Century" ASBESTOS-CEMENT PIPE



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No tuberculation
No electrolysis
No flow reduction

The "infections" that deteriorate the strength and capacity of water mains are just simply ruled out by the basic composition of K&M "Century" Asbestos-Cement Pipe. The limits of durability are extended indefinitely, yet this pipe is relatively light in weight.

Cost shrinkage begins with low shipping weight. Laying is done with low-cost equipment. Labor cost falls because this pipe is so easily placed, with any needed cutting and tapping done at the site. Time cost per joint is low and results are safeguarded by "Century" flexible couplings, with their ample latitude for radius and gradient.

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(*Continued from page 34*)

Harada, Masato B., c/o Territorial Highway Dept., Honomu, Hawaii (Jan. '48) *MR*

Harper, L. E., Pres., Omega Machine Co., 1141-43 Greenleaf Ave., Wilmette, Ill. (July '37) *P*

Harstad, H. T., 1514 Palm Ave., Seattle 6, Wash. (Jan. '42)

Humber, Joseph B., 4119 San Jacinto, Houston, Tex. (Apr. '47) *P*

Hunter, H. R., Cons. Engr., 313 E. 3rd, Wichita 2, Kan. (Jan. '47)

Jewell, George H., Sales Repr., Builders Iron Foundry, 1141 Greenleaf Ave., Willmette, Ill. (Apr. '34) *P*

Johnson, Francis M., Lt. Col., USAF (MSC), Office of the Surgeon, Headquarters Air Training Command, Barksdale Air Force Base, La. (Oct. '37)

Karr, Roy Warfield, Box 3085, Seattle 14, Wash. (Jan. '38)

Krause, Keith S., San. Engr., U.S. Public Health Service, Missouri River Basin Office, 417 E. 13th St., Kansas City, Mo. (Jan. '47) *MPR*

Kysar, J. P., Gen. Mgr., K. W. Eng. Co., 231 N. 11th St., Lincoln 8, Neb. (Jan. '47)

Lamar, Atwood A., 15358 Raymer, Van Nuys, Calif. (Oct. '43) *M*

Lanterman, W. G., City Mgr., Reed City, Mich. (Apr. '48)

Leonard, D. I., City Mgr., Route 4, Jonesboro, Tenn. (Apr. '49)

Linthicum, Howard M., 1882 S.W. 14th Terrace, Miami 35, Fla. (Jan. '48) *MPR*

Louis, Leo, Jr., Supt., Water Works Dept., City Hall, Cedar Rapids, Iowa (Jan. '42) *Fuller Award '47. P*

Lowe, Robert P., 3708 Millerton Ave., Pittsburgh 12, Pa. (Jan. '43)

Ludwig, Harvey F., Assoc. Prof. of Civ. Eng., 10 Engineering, Univ. of California, Berkeley, Calif. (July '39) *Goodell Prize '43. P*

Maffitt, M'Kean, 119 Bryan Ave., Wilmington, N.C. (Dec. '22) *Fuller Award '47. Honorary M. '49. M*

Morrill, Arthur B., World Health Organization, China Office, 106 Whangpoo Rd., Shanghai, China (Oct. '25) *P*

O'Reilly, A. R., 2136 Parkiomen Ave., Mt. Penn, Pa. (May '25)

Parks, Clare A., 5707—30th St., N.W., Seattle, Wash. (May '38)

Pearl, Emanuel H., Public Health Engr., Santa Clara County Health Dept., Hall of Justice, San Jose 18, Calif. (Jan. '37) *MPR*

Pearson, Erman A., Asst. Prof., Div. of Civ. Eng., Univ. of California, Berkeley 4, Calif. (Jan. '49)

Pena D., Luciano, Carrera 5, No. 6-17, Cali, Colombia (Apr. '46)

Poston, H. W., Asst. Basin Engr., U.S. Public Health Service, 215 Commerce St., Little Rock, Ark. (Oct. '34) *MP*

Poston, R. F., San. Engr., U.S. Public Health Service, Norman Bldg., Dallas 2, Tex. (Jan. '43) *PR*

Powers, John B., Mgr., Water Dept., Texarkana, Tex. (Jan. '47) *MP*

Quick, Robert L., 311 E. Church St., Gainesville, Fla. (Jan. '46) *P*

Reed, Paul W., 69 W. Washington St., Chicago 2, Ill. (Apr. '40) *P*

Riepe, Gerald E., Builders Iron Foundry, Inc., 1141 Greenleaf Ave., Wilmette, Ill. (Jan. '47)

Ruble, R. O., Cons. Engr., 3940 E. Anderson, Albuquerque, N.M. (Oct. '46)

Sanchez Mora, Jose Antonio, Urbanizacion Urdaneta, Oficina Banco Obrero, Maracaibo, Estado Zulia, Venezuela (Apr. '47)

Scruggs, Frederick T., Lynchburg Foundry Co., 1316 Peoples Gas Bldg., Chicago 3, Ill. (Oct. '48)

Seeger, William R., Asst. Gen Mgr. & Asst. Chief Engr., Marin Munic. Water Dist., 874—4th St., San Rafael, Calif. (Jan. '49)

Shope, Harlan Duncan, Civ. Engr., International Paper Co., Box 1649, Mobile 9, Ala. (July '47)

Smith, Sydney H., Route 4, South Haven, Mich. (July '41) *M*

Soffe, Benjamin F., 705 E. Broadway, Tucson, Ariz. (Apr. '44) *P*

Steel, Ernest W., Dept. of Civ. Eng., Univ. of Texas, Austin, Tex. (Apr. '47) *P*

Stein, Fred C., Jr., Div. Engr., New York City Dept. of Water Supply, Gas & Elec., Box D, Katonah, N.Y. (July '49) *MPR*

(*Continued on page 38*)

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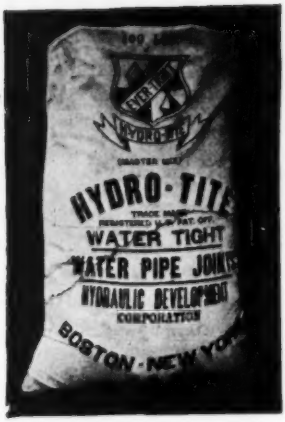

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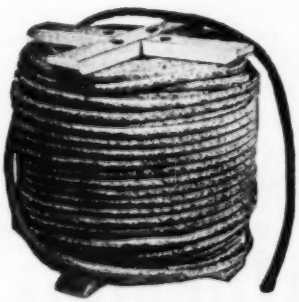

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(*Continued from page 36*)

Stewart, Morgan E., 621 S. Birch Ave., North Sacramento 15, Calif. (Jan. '44) *P*

Storm, Thompson A., Western Repr., R. D. Wood Co., 122 S. Michigan Ave., Chicago 3, Ill. (Mar. '34)

Swanson, Walter H., U.S. Pipe & Foundry Co., 625 Plymouth Bldg., Minneapolis 2, Minn. (Jan. '47)

Tapia-Murillo, Gustavo, 271 Boqueron, La Paz, Bolivia (Jr. M. Oct. '48)

Tatum, R. L., Engr., 331 Robinson Pl., Shreveport, La. (Oct. '45)

Taylor, Orville W., Carrier 15/10, Mishawaka, Ind. (Oct. '46)

Thomas, Howard S., Cons. Engr., 344 East Ave., Rochester 4, N.Y. (Apr. '49)

Tibbett, William M., 1822 W. 47th St., Los Angeles 37, Calif. (Oct. '43) *P*

Tillotson, Edwin S., Div. Supt., East St. Louis & Interurban Water Co., 23 N. Illinois St., Belleville, Ill. (Apr. '46)

Toth, Albert Steven, 639 W. 207th St., New York 34, N.Y. (Jan. '48) *PR*

Trostle, N. E., 1020 N. 15th St., Temple, Tex. (Oct. '42) *M*

Turner, Charles D., Mgr., Hot Enamel Sales, Koppers Co., Inc., Broad St. Station Bldg., Philadelphia, Pa. (Apr. '37)

Van Derwerker, Ralph J., Sr. San. Engr., Div. of Sanitation, U.S. Public Health Service, Washington 25, D.C. (Jan. '49)

Velz, C. J., 2122 Hill St., Ann Arbor, Mich. (Jan. '35) *P*

Walker, Vernon L., 414 Thomas St., Oak Park, Ill. (July '42) *P*

Wallace, Keith K., 72 Park Terrace W., New York 34, N.Y. (Oct. '49)

Weinberger, Leon W., Dept. of Civ. Eng., Case Inst. of Technology, University Circle, Cleveland, Ohio (Jr. M. Oct. '47)

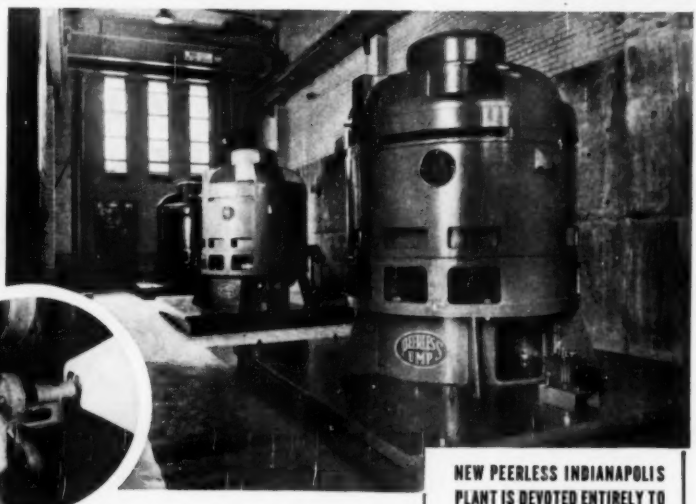
White, Lawrence S., 131 Kingswood Rd., Toronto 8, Ont., Can. (Jan. '43) *P*

Whyman, Lucy T. (Mrs.), Pres., Lavaland Water Co., Inc., 414 Coors Rd., Albuquerque, N.M. (Jan. '48)

Wilson, John R., 415 N. Texas Ave., Odessa, Tex. (Oct. '46)

Wolf, Harold W., Route 1, Luverne, Iowa (Jr. M. Apr. '48)

WIDEST CAPACITY RANGE



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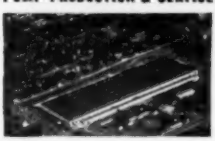

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Contents Contention

To the Editor:

I was somewhat amused at the "Doubt Rout," which appeared in the October issue. If nothing else, it proves that Tom Riddick and Rossum —as well as others—look at the frontispage picture.

It might be well if the pictures of microscopic organisms in Whipple's *Microscopy of Drinking Water* were brought up to date and supplemented with actual photographs, in natural color, of the common—and some not so common—organisms found in water.

There are quite a few photographs of microorganisms available. Why not compile them for distribution in ready form? Frankly, after many years of experience, I still resort to "smell" in order to differentiate between some forms of *Anabaena* and very similar forms of *Cylindrospermum* as viewed under a microscope with a 100 × magnification.

I should say there are still other "Doubt Routs" to be accomplished. If it is necessary to accomplish this by a picture on the front cover, let's have it; otherwise, the table of contents on the cover certainly helps a person who is either busy, or thinks he is busy. Martin Flentje's comments size it up pretty well.

LEE T. PURCELL

Cons. Engr.
1 Lee Place
Paterson, N.J.; Oct. 18, 1949

To the Editor:

As a reader of the JOURNAL for a good many years past, I am going to take the side of the members who prefer to return to the former "contented" cover. I agree that the former cover carries the appearance of a technical journal to a much greater degree than does a pictorial cover; that information or articles are much more easily and quickly found when the contents of the JOURNAL is printed on the cover. To me the JOURNAL with the pictorial cover looks too much like any commercial magazine, and it is far from that.

I also agree with those who ask for

(*Continued on page 42*)

PALMER *Filter Bed* AGITATORS

Prevent Sand Beds From Cracking
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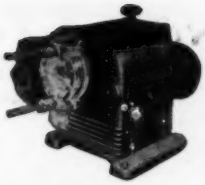
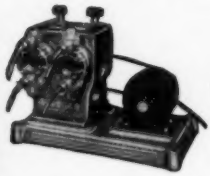


Heavy Duty Chem-O-Feeder
0-8 gal./hr. 0-100 lbs./sq. in.



Duplex Chem-O-Feeder
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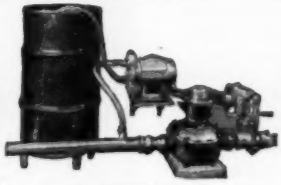
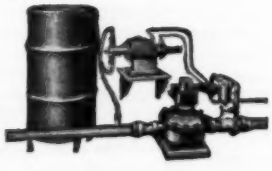
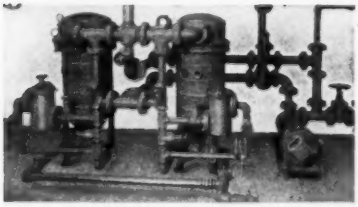


Low Pressure Automatic and Proportional Chem-O-Feeder
0-5 gal./hr. 4-100 lbs./sq. in.



High Pressure Automatic and Proportional Chem-O-Feeder
0-5 gal./hr. 30-200 lbs./sq. in.



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(*Continued from page 40*)

larger type for the volume and page numbers and the month on the backbone of the JOURNAL. I am like Vic Weir in that it seems to me that printing is getting smaller all the time; illumination is becoming poorer; stairs are getting steeper; and the younger generation is much more uncontrollable than we were. Could we be getting older?

PAUL D. COOK

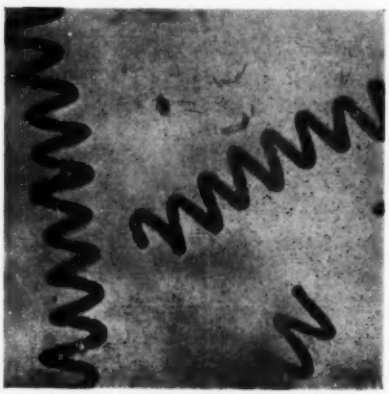
Sanitary Engineer
Lake County Water Dept.
Painesville, Ohio; Oct. 5, 1949

Whatever else, type will get larger next year.—ED.

Photo Finish

From the Editor:

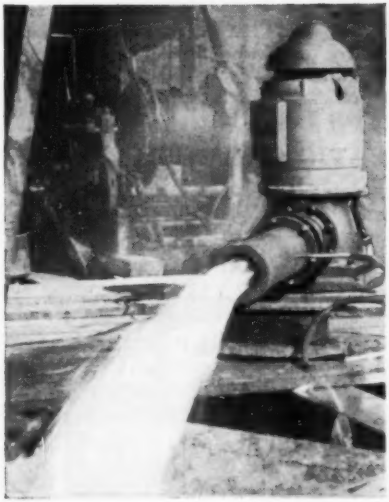
An editorial slip unwittingly weakened George F. Turre's evidence (October correspondence section, p. 42) that Anabaena *was the correct identification for the curly string of organ-*



Courtesy "Taste and Odor Control Journal," Vol. 13, p. 3 (April 1947)

ANABAENA

isms depicted on the August cover. The confirming photograph made by Merkel, "as shown in the reproduction herewith," was neither here nor there; we were sitting on it. We present it now (we hope), complete with tell-tale heterocysts and coils.—ED.



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WELL WATER SYSTEMS

Condensation

Key: In the reference to the publication in which the abstracted article appears, **39**:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, **39**:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *B.H.—Bulletin of Hygiene (Great Britain)*; *C. A.—Chemical Abstracts; I. M.—Institute of Metals (Great Britain)*; *P.H.E.A.—Public Health Engineering Abstracts; W.P.R.—Water Pollution Research (Great Britain)*.

AQUATIC ORGANISMS

Actinomycetes in Reservoirs as One of the Causes Responsible for the Earthy Smell of Their Waters. B. L. ISACHENKO & A. A. EGOROVA. Microbiology (U.S.S.R.) **13**:216 ('44). Bact. and actinomycete counts in water from Moscow R., its tributaries, and various reservoirs seem to indicate correlation between actinomycete count and appearance of earthy smell. Causes of contamn. many; control seems to be removal of accumulated org. matter from reservoirs. Counts on surface water do not show organisms; bottom sediments must be included.—*P.H.E.A.*

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New Experiences on Biologic Damage to Raw Water Supplies. HERBERT BEGER. Gesundh.-Ing. (Ger.) **69**:6:172 ('48). Reported that industrial supply clogged by ¾" long snail *Physa heterostropha* which likes to live in warm water. Clogging of cooling-water lines due to mussel *Dreissensia polymorpha* accompanied by fresh-water sponges, moss animalcules and red larvae of Chironomidae also reported. Raw river water contained many other mussels and snails which did not develop in the pipes. These animals can be killed in pipes by 2.5 ppm. chlorine, but must then be removed by salamanders. Periodic chlorination can prevent their growth and biologic traps with fascines can reduce their entrance. Cause of sudden wholesale appearance of mussels has been shown to be reduction of certain types of pollution owing to war-induced shutdown of factories upstream. Fresh-water sponges, such as Gemmule of mustard seed size, can enter such water systems. As grown sponges contain silica needles, they should not be touched with hands on cleaning. Moss animalcules form motile statoblastes that can even pass filters and have been found clogging filter nozzles with their later growth. Most statoblastes float and can be removed before they reach filters.—*Max Suter.*

British Water Weeds. ERIC HARDY. Wtr. & Wtr. Eng. (Gt. Br.) **51**:417 (Sept. '48). Growth of sudd on Upper Nile, blocking of American rivers by water fern *Azolla* and nuisance of water hyacinth (*Pontederia eichornia crassipes*) in northern rivers of New South Wales and Queensland exam-

(*Continued on page 46*)

. . . for DOUBLE SAVINGS

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(*Continued from page 44*)

ples from abroad. Foreign water weeds sometimes invade British waters, like American water weed *Elodea canadensis*, which overran inland waters in last century. Floating American water fern *Azolla* appeared on surface of ponds and rivers in Norfolk, Middlesex and Cheshire. Water weed *Hydrilla verticillata* appeared at Esthwaite Water early this century. Aquatic flowers often ominous to water engrs. Lovely water hawthorne (*Aponogeton distachyon*), Cape Pond weed native of South Africa, spreads quickly over lakes in Britain, adapting itself to various water levels. By water weeds one implies true aquatics or fully submerged plants. Main nuisance lies in fact that hardly any rely on seeds. Small fragments of leaves or stems sufficient to grow new colonies. By day they oxygenate water. Such plants as *Elodea* live free of roots or surface leaves. Plant obtains food by diffusion through thin skin. Most water weeds spend winter as bud on bottom. Moss-like algae choked 400 acres of Hickling Broad in Norfolk in early '30's. When it died it deoxygenated water, killed fish, and smell was objectionable. Algae or green-slime plants alter taste of water. *Synura* imparts cucumber odor. *Beggiatoa alba* and *Steoclonium tenue* sign of poln. Desmids thrive in acid soft water. Diatoms choke filters. *Chlamydemonas* turns water green and passes through filter. In '36 *Fragilaria crotonesis* deposited 63 tons of silica which choked London filtration plant. Most of trouble occurs in late summer and autumn. Ordinary weed growths can be kept down by raking. Algicides and other chem. poisons may be used. Water may be impregnated with salt. Fish life to be preserved restricts use of chem. poisons. Algicides include chloramine, copper sulfate, and minute quants. of potassium permanganate. They do not affect all algae, particularly surface-floating forms such as

(*Continued on page 48*)

Here's all you need to repair a KENNEDY SAFETOP after collision damage

Only one man with a socket wrench

a large screw driver

a light sledge hammer

one collision breakage repair kit (breaking ring, coupling, 2 pins, gasket)

and 30 minutes

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(*Continued from page 46*)

Oscillatoria rubescens. Certain freshwater sponges, shellfish, and minute polyzoa feed on algae. Iron-abstracting bacteria like *Crenothrix* and *Gallionella* stain water rust-colored. Ducks, moorhens, coot and swans are important agents in weed distr. Water weeds in England less troublesome than submerged water plants. There are about 80 water weeds in flora including about 30 stoneworts and 21 *Potamogetons.* Latter, and water thyme *Elodea,* perhaps most troublesome. *Potamogetons* numerous and live floating in water without rooting. Author found *Potamogeton perfoliatus* in village water reservoir in Syria. It grows in waters of Britain, America, Australia and elsewhere. Two species of water milfoils grow abundantly in English fresh waters. Seeds lie on bottom several years until mud bed exposed when they quickly germinate and live terrestrial life until water rises again. Pink flower-spikes of floating periscaria (*Polygonum hydropiper*) have filled indus. reservoir in south Lancashire. Other water plants that choke surface are duckweed and white water crowfoot which cover large lakes like snow. In smaller waters bogbean, white or yellow water lily, *Polygonum natans* and alien *Azolla* do this. Of 9 species of water thymes or *Elodeas,* only American troublesome in England. It now inhabits almost every fresh water in Europe. All plants are females which have spread by vegetative reproduction only. Few male plants in Scotland but recent introductions. Another submerged plant, American *Hydrilla verticillata,* grows up to 16" high in 5 to 10′ of water. Hornwort (*Ceratophyllum demersum*) found in Britain, usually in slow streams and shallow margins of lakes. It should not be confused with horned pondweed (*annichella palustria*) which is never much trouble. Barges play

(*Continued on page 50*)

Woofproof Your Metermen

Here's a bible of bark and bite that will enable you to improve both your personnel relations and your public relations. See that every meter reader gets a copy. Make him read it! Make him heed it!

Under the cover reproduced herewith, A.W.W.A. has, in response to the demand of several meter departments, reprinted Bruce McAlister's "Bow-wow, Mister Meterman" as it appeared in the July issue of **Public Relations at Work.** As a six-page booklet, this practical advice to the doglorn is now available at a nickel per copy—much less than the cost of a single patch in the seat of your pants.

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(*Continued from page 48*)

large part in distr. of yellow water lily, for seeds, buoyant at first, become water-logged and sink. Great weed growth often follows slight poln. by sewage. Later weeds die off with resulting putrefying.—*H. E. Babbitt.*

WATER QUALITY

The Influence of Waters of Various Origins Upon the Quality of the Water Supply. JOZEF RYNARZEWSKI. Gaz, Woda i Tech. Sanit. (Poland) **22**:308 (Oct. '48). All ground waters have individual characteristics dependent on and varying with source. Author contends that initial chem. anals. on individual sources constituting water supply insufficient in that chem. changes may and do occur when waters from different sources mixed. These reactions occur in water mains carrying water to treatment plant as well as in distr. system itself. Experience of Wroclaw (formerly Breslau, Germany) cited where waters high in org. matter from infiltration galleries mixed with ground waters high in iron carbonates with result that protective colloids formed, making pptn. of iron more difficult, leading to chem. pptn. Water supply for city of Poznan and its difficulties resulting from intermixing of various waters described. Mixt. of 4 waters feed well fields serving as source of supply: [1] natural infiltration from Warta R., [2] Warta R. water passing through infiltration galleries, [3] normal ground water whose direction of flow parallels river and [4] waters entering well field during times of flood. Chem. anals. which were made of water from various wells feeding 2 collectors serving Poznan showed great changes. Previous calcns. have indicated that ground waters acct. for about 2% of flow and flood flows provide negligible amt. of flow, but that most of flow obtained from natural infiltration and infiltration galleries. For '47 flows, this

(*Continued on page 54*)

ENOUGH SAID

1925 Charlotte, North Carolina
Filtration Capacity—8,000,000 gallons per day
Mechanical Equipment—Roberts Filter

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Filtration Capacity—Increased to 16,000,000 gallons per day
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This proof of continuing satisfaction is only one of many recorded by users of Mechanical Equipment by Roberts Filter—evidence certainly of the basic fact that Roberts Filter equipment is never orphaned.

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No community should have to take up, replace, and *pay twice for* a water distribution system. But it has been done! Whole systems, constructed with other kinds of pipe, have been dug up because of ruinous maintenance costs, and replaced with cast iron pipe.

Why should any community planning a public water supply system, or extensions to an existing system, contemplate such a risk? When it is well known that many cities in the United States and Canada have cast iron water mains in service that were installed over a century ago. And a survey conducted by eminent water works engineers shows that 96% of all six-inch and larger cast iron water mains *ever laid* in 25 representative cities are still in service. And reports from 195 water works superintendents show that the maintenance-cost of cast iron mains is little or nothing.

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CAST IRON PIPE

--paid for but once!

SERVES FOR CENTURIES

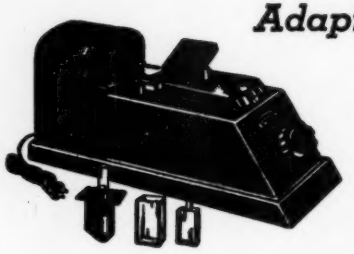
(*Continued from page 50*)

ratio was about 60% from natural infiltration and 40% from infiltration galleries, varying over wide limits during shorter periods of time. Intermixt. of these waters contg. some oxygen and iron carbonates caused pptn. of iron salts, clogging well field, well screens, collectors, etc. With removal of this easily precipitable iron, remaining iron more difficult to remove by aeration and filtration. During times of flood much org. matter may collect in filters and may undergo decompn. with production of sufficient CO_2 to lower pH to such level that pptd. iron may be dissolved. Data presented indicate that this may have happened during periods when floods prevalent, because final effluent had higher concn. of iron than during other periods of operation. These chem. interactions may occur in distr. system after waters have been treated. As example of this, author cites experience of Frankfurt-am-Main whose water supply taken from 8 sources, 2 of which are spring supplies and remainder ground water supplies. Chem. characteristics of these 8 supplies tabulated and corrosiveness of individual sources and mixts. noted. In conclusion, author states that it may be possible to improve certain supplies by judicious mixing of water from various sources (utilization of natural coagulating ability of certain waters and corrosion control).—*Conrad P. Straub.*

The Influence of Seasonal Factors on the Quality of Bank-Filtered Rhine Water. G. B. ROEMER. Gesundh.-Ing. (Ger.) **69**:44 ('48). Author reviews literature concerning bank filtration of river water and relation between bank-filtered and ground wa-

(*Continued on page 56*)

KLETT SUMMERSON
ELECTRIC PHOTOMETER



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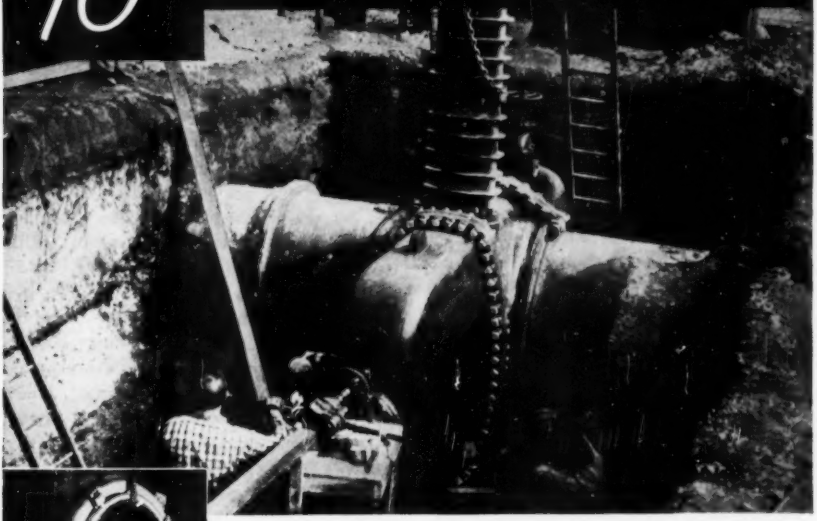

Section removed from main

Finished insertion

CUTTING THE MAIN. Illustration shows cutting dome, temporary shut-off valve and permanent valve body in place.

At a large Eastern steel mill uninterrupted production depended upon a thirty year old, 48" cast iron main, carrying sea water used for cooling the furnace jackets. The main was in poor condition — badly corroded and electrolytically pitted.

In order to provide an emergency by-pass in the event of line failure, a gate valve was required. Since the mill could not risk even a momentary shut down, Smith was asked to insert the valve under pressure. Although of unprecedented size, the insertion was completed in four days without interruption of service or reduction in pressure.

*First 48" insertion ever made under pressure. One month later a second 48" gate valve was inserted by Smith for the Water Bureau, Philadelphia, Pa.

29

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Yes—but

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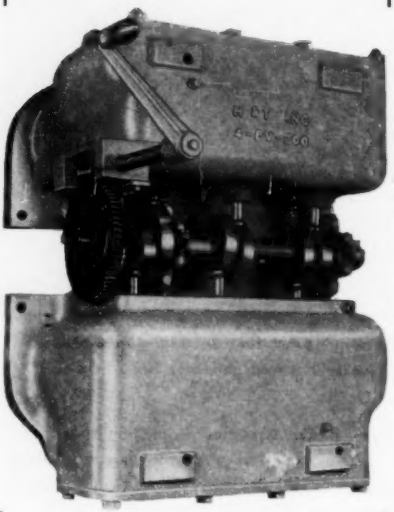

This valve, built in all sizes and for all requirements, is a masterpiece of workmanship and operating simplicity. It is available only to experienced water softener manufacturers.

Designed, built and guaranteed by

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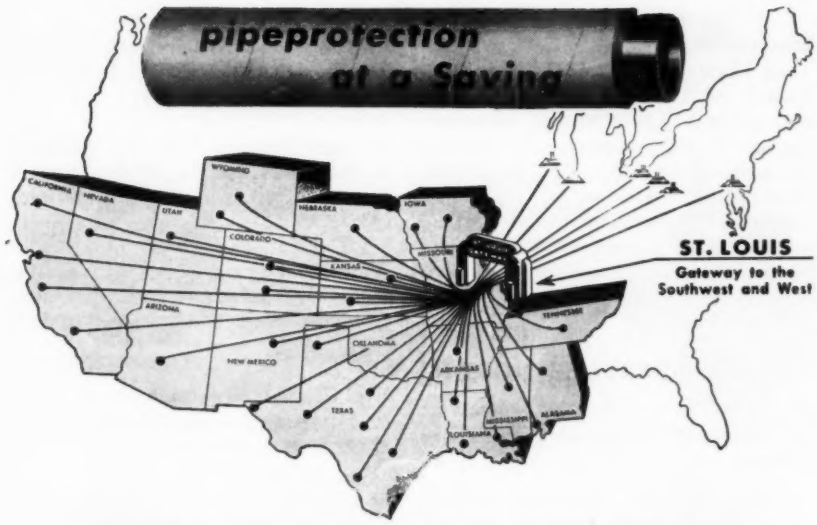
(*Continued from page 54*)

ter, with special reference to water works on rivers Ruhr and Rhine, and discusses factors affecting bank filtration and qual. of bank-filtered water. Discusses effects of rate of flow and level of river, compn. and thickness of filtering layer of sand or gravel and org. sediments, and seasonal factors, such as temp., sunlight, rainfall, melting snow, formation of ice and growth of algae and other organisms. Describes investigations made during '39–'42 on chem. and bact. characteristics of water from river Rhine and of bank-filtered Rhine water from wells supplying town of Düsseldorf. Results, given in diagrams, show increase in number of bacteria in both well and river water during colder months, generally when there was sudden rise in level of Rhine; frost affected biol. processes during filtration. In dry weather, increased withdrawal of water might, by increasing rate of filtration, decrease purifying effect. Occurrence of *Esch. coli* in unchlorinated well water usually accompanied by increase in total number of bacteria but can often be regarded as indication of disturbance in bank filtration. Content of nitrogen in well water, though usually higher than in river owing to oxidation processes in ground, subject to similar fluctuations in well and river water. Content of nitrate in well water varies with that in river water but higher in well water where content of ammonia and nitrite lower. Org. matter reduced by bank filtration to $\frac{1}{3}$–$\frac{1}{4}$ of content in Rhine water. Content of nitrogen compds. and oxygen demand give indication of efficiency of bank filtration. Content of chloride in both waters affected by level of water; independently of variations thus introduced, there was, during period of investigation, continuous increase in content of chloride. No relation could be traced between results of chem. and bact. examns.—*W.P.R.*

(*Continued on page 58*)



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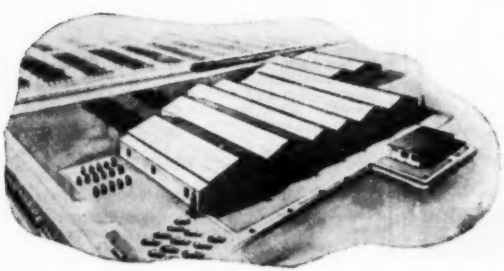


Our plant, handling the smaller diameters of pipe, is now in operation. For full information about schedules write today.

(Continued from page 56)

Mineral Waters. G. VAN BENEDEN. Tech. l'Eau (Belg.) **2**:4:23 (Apr. '48). Theory of Theobald and Nussberger that mineral waters formed as consequence of transformation of pyrites considered incorrect. Mineralization conceivable if presence of Trias and action of CO_2 on chalk and, to degree, on Na and Mg considered. Fe may be brought in solution through action of carbonic acid or traces of H_2SO_4.—*Willem Rudolfs.*

OTHER ARTICLES NOTED

Recent articles of interest, appearing in American periodicals not abstracted, are listed below.

A New Simplified Approach to Mathematically Calculated Reserves for Depreciation for Accounting Purposes. WALLACE E. CARR. Land Economics, **25**:3:304 (Aug. '49).

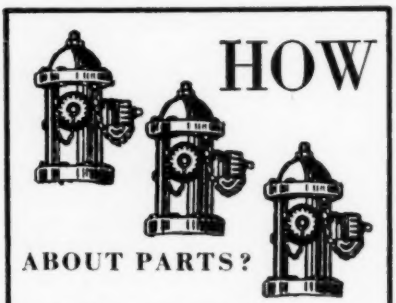
Twice as Much Water for Cincinnati. R. E. DUHME. Eng. News-Rec., **143**:12:30 (Sept. 22, '49).

Network Flow by Electrical Analogy. H. A. PERRY JR., D. E. VIERLING & R. W. KOHLER. Eng. News-Rec., **143**:12:19 (Sept. 22, '49).

Waterproofing of New and Old Masonry Structures. R. N. PRETSCH. J. Maine Wtr. Utils. Assn., **25**:5:89 (Sept. '49).

The Cost of Corrosion to the U.S. H. H. UHLIG. Chem. & Eng. News, **27**:39:2764 (Sept. 26, '49).

Engineering Aspects of Cathodic Protection as Applied to Pipelines. E. P. DOREMUS, G. L. DOREMUS & M. E. PARKER JR. Corr., **5**:9:273 (Sept. '49).



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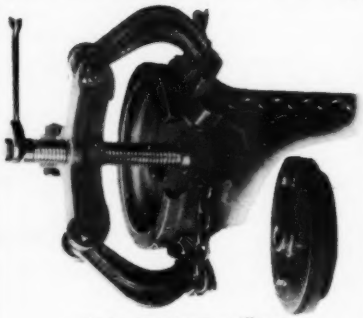

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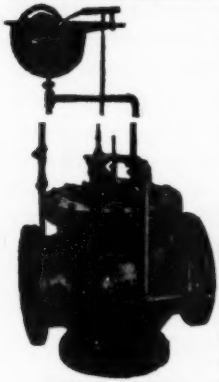

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Electric remote control—solenoid or motor can be furnished

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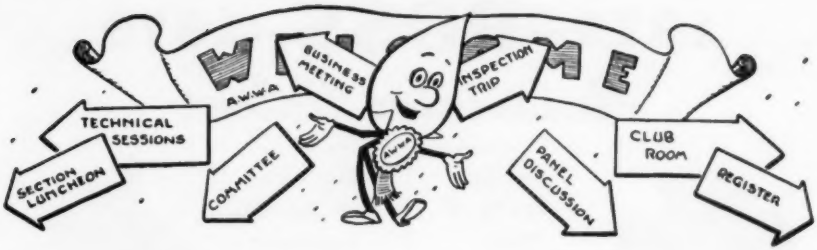


Section Meeting Reports

New York Section: The regular Fall Meeting of the New York Section was held at Cooperstown, N.Y., on Tuesday and Wednesday, Sept. 6 and 7, 1949. There were 250 members and guests present in the very historical town. Headquarters were at the beautiful Otesaga Hotel.

Of particular interest at this meeting were the speakers, including Glen R. Bedenkapp, Commissioner of the State Public Service Commission; Dr. Allan Stockdale, of National Assn. of Manufacturers, New York City; Lovett C. Peters, Bankers Trust Co. of New York, and Earl Devendorf, Director of the Div. of Environmental Sanitation, State Health Dept.

Following the banquet, a social hour was arranged through the courtesy of the Water and Sewage Works Manufacturers Assn. This form of entertainment seems to have worked out most satisfactorily, in that it gives many of the newer members an opportunity to meet the older ones.

The Round Table Conference and Panel Discussion, led by Simon P. Carman, Binghamton consultant, evoked the interest that always greets such forums. Nearly all the members of the Section who were present attended this conference and partook in the various topics of particular interest to themselves. This panel discussion seems to bring forth from many of our new members a much keener interest in their own problems than do the stereotyped, too-technical presentations which we have sometimes had. The topics discussed included: diesel engines, labor problems, legislation, ground water supplies, water softening, water works schools, upflow flocculation and diatomaceous filters. The Spring Meeting of the Section will be held in March at Rochester. The members voted almost unanimously to continue the type of meetings at resort hotels available after Labor Day, and probably the 1950 Fall Meeting will be held at Lake George.

R. K. BLANCHARD
Secretary-Treasurer

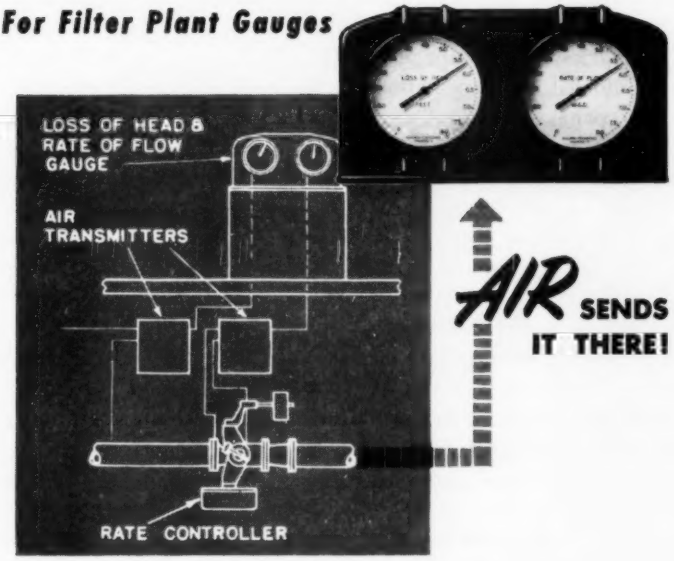
Minnesota Section Meeting: The 33rd annual conference of the Minnesota Section was held in Minneapolis Sept. 8 and 9, and the interest

(Continued on page 62)

BUILDERS

Pneumatic Telemeter

For Filter Plant Gauges



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BUILDERS PROVIDENCE

Instruments

(*Continued from page 60*)

shown at the sessions was certainly a compliment to the program committee, although attendance dropped somewhat from the 1948 record.

The subject of "Nitrates and Infant Cyanosis" was ably handled by Herbert M. Bosch, A. C. Rosenfield, Roberta Huston, H. R. Shipman and F. L. Woodward. Their efforts and work will certainly reduce the incidence of "blue babies." A. E. Griffin's paper, "New Concepts in Water Chlorination," dwelt on refinements of water treatment which should reduce that "irreducible minimum" which stops most of us from producing a perfect drinking water. "Rethinking Water Rate Schedules" was covered by LeRoy Harlow, city manager, Fargo, N.D. An unusual amount of discussion followed his presentation of the subject.

The two panel discussions were handled by E. R. Mathews and U. J. Seibert. More questions were asked and many more attending the sessions participated than at any previous conference. Panel discussions definitely have a place on every program.

With speakers like Kenneth V. Hill and Arthur E. Gorman assigned to "Synthetic Detergents and Municipal Water Softening" and "Radioactivity—A New Criterion of Water Quality" respectively, the subjects were well covered.

Immediately after the business luncheon George Schroepfer introduced George Peterson, editorial writer, who presented H. G. Tischer, the Section Chairman, with a watch pendant and a leadership recognition award on behalf of the *Minneapolis Star and Tribune*. The award was conferred because of Tischer's long and outstanding record with the city of Duluth and with the A.W.W.A.

A.W.W.A. Vice-President W. Victor Weir gave a report on the "State of the Association" and discussed its future planning. Mrs. A. C. Bromschwig, Chairman of the Ladies' Committee, arranged for a Friday noon luncheon at Dayton's Sky Room for the 30 ladies who were present.

At the banquet, in addition to the state entertainment, Dr. Wendell White, eminent psychologist of the University of Minnesota, spoke on "Psychology in Living."

R. M. FINCH
Secretary-Treasurer

Pennsylvania Section Meeting: The Pennsylvania Section held its first annual meeting September 14 to 16, 1949 at the Penn-Harris Hotel, Harrisburg, Pa. The total attendance was 165, including members and guests. Greetings were brought to the gathering by Claude R. Robins, Mayor of Harrisburg.

The technical program, presided over by Chairman Elbert J. Taylor, was opened by H. E. Moses, consulting engineer with the Pennsylvania Dept. of Health, who discussed "What the Clean Streams Program Will

(*Continued on page 64*)

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Simplex Air Inlet Valves admit air in large quantities should a line break occur and permit the expulsion of air when lines are being filled. Thus thin walled pipes are protected from collapse.

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(*Continued from page 62*)

Mean to Pennsylvania Water Works." This topic was commented on by E. C. Trax, Chemist of the McKeesport Filtration Plant, and John F. Kegebein, Jr. of the Norristown Water Co. A panel on "Service Materials and Service Main Construction" followed, conducted by Charles P. Abraham of the Lancaster Bureau of Water, with E. C. Goehring of the Beaver Falls Municipal Authority; G. B. Gustafson, engineer, Wilkinsburg-Penn Joint Water Authority, Wilkinsburg; and J. D. Johnson of the Erie Bureau of Water; as members of the panel discussing the subject. J. D. Carpenter of Gannett, Fleming, Corddry and Carpenter presented an excellent paper entitled "An Unusual Water Supply Problem."

The Thursday morning technical session was presided over by E. C. Geohring, Vice-Chairman of the Section. The first paper was presented by Harry A. Faber of the Chlorine Institute on "The Status of Water Fluoridation in 1949" and was ably discussed by L. G. Grace, Chief of the Dental Division, Pennsylvania Dept. of Health. Another panel on "Policies Concerning Metering, Service Main Extensions and Shutoffs" was presented by E. O. Kable of the York Water Co. and discussed by W. H. Bottelsen of the Municipal Authority of the Borough of Oakmont and Carl I. Kear of the Municipal Authority of the Borough of Minersville. "Development of the New Water Supply for the City of Chester" was the topic expounded by Francis S. Friel of Albright & Friel and discussed by K. C. Armstrong of the Chester Municipal Authority.

The afternoon session was directed by M. G. Mansfield, Section Director. The first technical presentation was a panel on "Security Programs for Water Works Personnel" led by W. H. Markus, Pittsburgh attorney, and ably discussed by K. A. Glenz of the Municipal Management Co., Lemoyne, Thomas R. Lathrop of the Ohio Department of Health, F. B. Marsh of *Water Works Engineering*, and George W. Naylor of the Vandergrift Water Co. Royden N. Aston of the Mathieson Chemical Corp. gave a paper on "Recent Developments in the Chlorine Dioxide Process," which was discussed by R. B. Adams of the Wilkinsburg-Penn Joint Water Authority and B. French Johnson of the New Castle Water Co. Fred E. Stuart of the Stuart Corp. presided over a panel discussion on "Factors Affecting Coagulation and Flocculation" and was ably assisted in the discussion by Richard W. Ockershausen, General Chemical Div., Allied Chemical & Dye Corp., and H. E. Holloway of the Midland Water Co.

The technical session on Friday was presided over by T. H. Kain of the Columbia Water Co. James H. Allen of the Interstate Commission on the Delaware River Basin discussed "Delaware River Basin Tri-State Water Project" and Elwood L. Bean of the Philadelphia Bureau of Water presented a paper on "Preliminary Ozonation at Philadelphia." This was

(*Continued on page 66*)

20-Mile Steel Water Main Has Arc-Welded Field Joints

The picture above was taken recently during installation of a 20-mile steel water main by the City of Minneapolis. Throughout the length of the 48 in. I.D. x ⅜ in. main, metallic arc-welded joints were used exclusively. There was no need for auxiliary fittings, the only special equipment required being a simple cylindrical assembly jig. Welding was done in accordance with AWWA Specification 7A.8-T, and each weld was coated both inside and outside with tar enamel.

Minneapolis Water Department engineers report the following advantages of this method of water-main construction: (1) It saves man-hours. (2) It produces leak-proof joints that can be covered with earth as soon as each weld is coated. (3) Hydrostatic testing is not necessary prior to back filling. (4) Streets can be reopened to traffic with a minimum of delay. (5) The possibility of rain damage and washouts is reduced. (6) Accident hazards are minimized.

Bethlehem Tar-Enameled Water Pipe was chosen for the job because of its economy and speed of installation. Bethlehem Tar-Enameled Water Pipe is formed from sound steel plate, and is then carefully welded and tested in the shop. It offers excellent resistance to corrosion and incrustation because it is machine-coated with a uniform layer of protective tar enamel.

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BETHLEHEM *Tar-Enameled* WATER PIPE

(*Continued from page 64*)

followed by a presentation of the motion picture, "Installing Cast Iron Pipe," through the courtesy of the Cast Iron Pipe Research Assn.

At the annual banquet held on Thursday evening, Dr. A. P. Black, President of the American Water Works Association, addressed the gathering, bringing the greetings of the Association to one of the two baby sections. Dr. Black stirred up interest in membership with his talk and a formula he presented. He advised the members that their section could be one of the largest if its potentialities were achieved.

The Water and Sewage Works Manufacturers Assn. provided club room entertainment for the members at a social gathering on Wednesday evening and again at a social hour preceding the banquet Thursday.

L. S. MORGAN
Secretary-Treasurer

Rocky Mountain Section: The 23rd annual meeting of the Rocky Mountain Section was held in the Acacia Hotel, Colorado Springs, on Sept. 22 and 23, 1949, with 86 registrants in attendance. Walter Knenning, assistant city manager, welcomed those attending the meeting.

A.W.W.A. President A. P. Black gave some data on the importance of the smaller water systems in the country, and noted that Colorado is over the average and Wyoming, New Mexico and Utah under the average for members in this class. A membership drive is indicated. Chairman Henry Krull then spoke of the need for better public relations and publicity. He also deplored the water personnel turnover due to politics.

Jean S. Breitenstein, attorney, then gave a very interesting and informative paper on "Legal Aspects of Transmountain Diversion as Related to Municipal Use." "Diversion of Water Funds to Other City Uses" was presented by D. D. Gross of the Denver Water Dept. Angus Slee of Longmont, Colo., led the discussion.

J. Orville Jones of the Pueblo, Colo., Water Works gave some pertinent facts relating to "Collection and Distribution of Water." Thomas

(*Continued on page 68*)

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(*Continued from page 66*)

J. Eaton, Water Dept., Public Service Co., of New Mexico, Santa Fe, led the discussion.

The last item on the Thursday program was a motion picture "Gift of a Glacier" presented by R. E. Baumberger of Boulder, Colo., which showed the location of the watershed and collecting reservoirs from which Boulder gets its water supply .

On Friday George J. Turre of the Denver Water Dept. gave an interesting talk on "Algae Control and Photomicrographs" which was followed by general discussion on control of algae and effects of copper sulfate.

"Pipe Jointing Compounds" was presented by Frank Rosich, Div. of Sanitation, Colorado State Dept. of Public Health; and a lively discussion, principally relating to sulfur compounds, was led by W. H. Millikin of the Denver Water Dept.

"The Status of Water Works Materials" was discussed by Dana E. Kepner, Jack Davis, J. O. Brown, Jim Warner, Ralph Tracy and A. D. Mars Jr., all manufacturers' representatives of Denver. They stated that most water works materials are now available in relatively short periods of time, and some may be shipped from stock. A few items remain in the scarce class.

A business luncheon was held on Friday and 67 attended. There was some discussion of the place where the next school sessions and annual meeting should be held; the choice was left to the governing boards for decision.

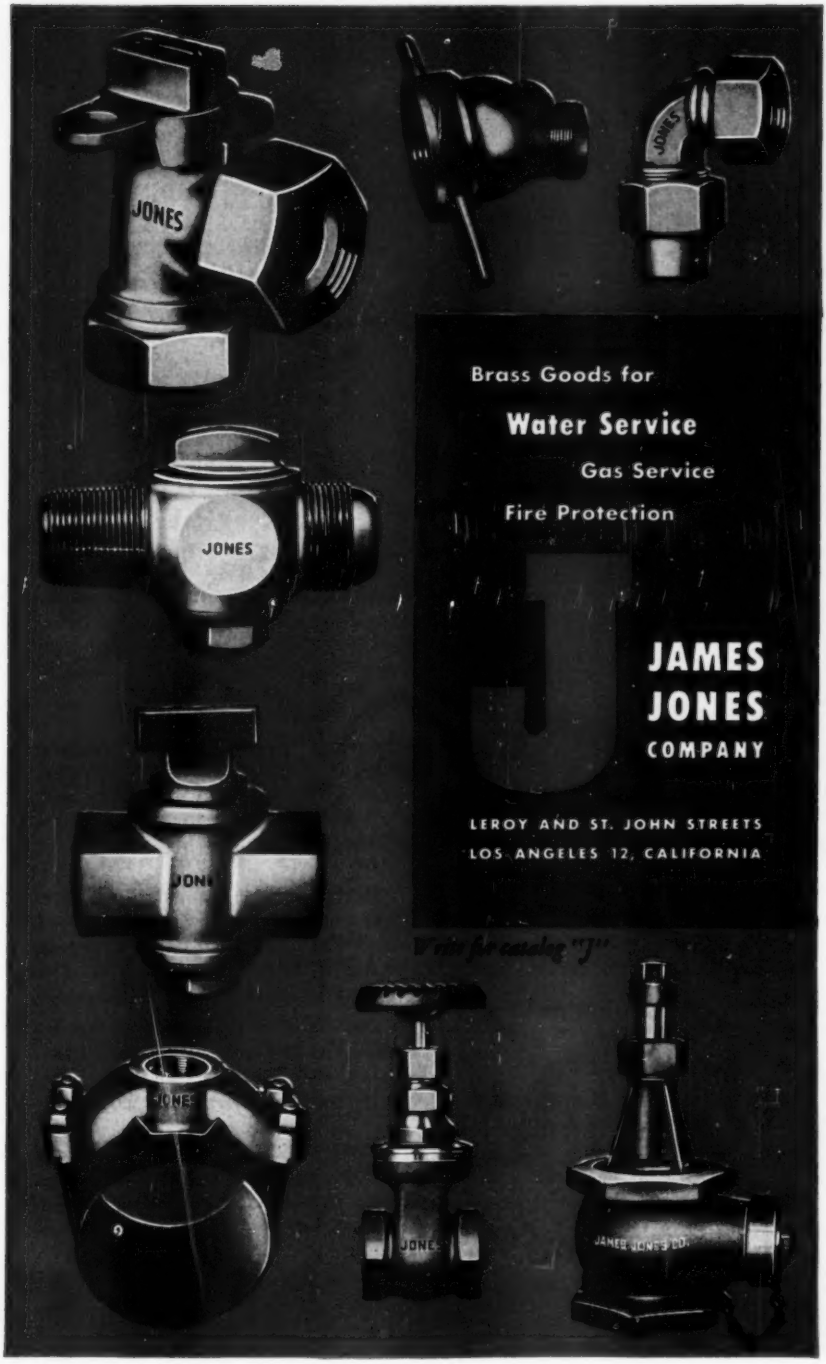
In the afternoon, a sound motion picture "The Test of Time" was presented. This picture, prepared by Layne & Bowler, Inc., Memphis, Tenn., showed the development of a well water supply. John M. Hunter Jr. of the Cheyenne, Wyo., Filter Plant presented a paper on "Design and Operation of Small Water Works." The paper was discussed by L. C. Osborn and O. J. Ripple, Denver consultants. Dr. Black also contributed to the discussion of this subject.

"The Availability of Radio for Water Works Operation" was the title of a paper given by J. M. Wissenbach, Chairman of the Rocky Mountain Utility Radio Assn. Considerable interest in this paper was evident and also in the equipment displayed.

The Ladies Entertainment Committee took the visiting ladies on a tour of the city Thursday and to a bridge luncheon on Friday.

The banquet on Friday evening was attended by 93 men and women who enjoyed a floor show featuring local talent. The resolutions committee report was read by Dana E. Kepner, and the new chairman, B. V. Howe, presented the retiring chairman, Henry Krull, with the Chairman's Pin.

O. J. RIPPLE
Secretary-Treasurer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"Corrosion Service Piping" is the title of a handsomely colored and illustrated 32-page booklet issued by Taylor Forge & Pipe Works, Box 485, Chicago 90. It includes a historical section on the evolution of "I.P.S." (Iron Pipe Size) and tables illustrating its applications, design tips, and dimensional and other data on stainless steel and nickel alloy piping.

A "Dutch Boy Metal Painting Handbook" issued by the National Lead Co., 111 Broadway, New York 6, contains 96 pages of information on anticorrosion coatings for metal structures, ranging from elementary corrosion theory to formulas and specifications for paints.

"Paving Breakers and Sheeting Drivers" produced by Worthington Pump & Machinery Corp., Harrison, N.J., are the subject of Bul. H–1200–B40, available upon request.

Electric hammers for drilling holes in concrete, brick or rock are described, priced and illustrated in a four-page bulletin available from Syntron Co., Box 220, Homer City, Pa. Also shown are special drills, chisels and other tools. The hammers utilize both a percussive and rotating motion to drill and round the hole simultaneously.

Water conditioning equipment offered by the Elgin Softener Corp., Elgin, Ill., is the subject of a 20-page brochure, Bul. 610, which is available on request. Included are zeolite softeners, chemicals, boiler feedwater treatment systems, filters and aerators.

(*Continued on page 72*)

A FREE COPY will gladly be mailed to anyone concerned with water conditioning and waste treatment problems. Here's an interesting 8½ by 11 inch bulletin containing 28 pages of factual information about the ACCELATOR . . the modern, proven, high-rate water treating plant. It's filled from full color cover to cover with installation pictures, charts, graphs and tables. The text, although scientific, is written in terms any layman can readily understand. Among the subjects covered are: 1. Historical development, 2. Accelator Apparatus, 3. The Process, 4. Distinguishing Characteristics, 5. Advantages, 6. Design, 7. Operation, 8. Applications, 9. Specifications, 10. Bibliography. Be familiar with the ACCELATOR . . the outstanding development of the 20th Century in the field of water conditioning. Send for your copy today. Use company letterhead or fill in and mail the convenient coupon below!

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(*Continued from page 70*)

Setting and testing equipment for water meters is described and illustrated in Catalog 50 of the Ford Meter Box Co., Wabash, Ind. An impressively produced, 94-page book, it also contains general information on the how and why of meter installation and testing. Prices are also shown.

Rebuilding worn packing areas by metallizing is discussed in the September issue of Metco News, issued by Metallizing Engineering Co., 38–14 30th St., Long Island City 1, N.Y.

The spraying or metallizing of corrosion-resistant coatings on metal tanks, as well as the building up of pump casings and impellers and other worn metal parts, is described in a bulletin issued by Metinc, 3844 S. Wallace St., Chicago 9, Ill. The firm specializes in contract metallizing and provides both workmen and equipment on a contract basis.

Mercury switches, which provide trouble-free, dependable electrical switching through the conductive action of a sealed-in pool of mercury as it is tilted towards or away from the electrodes, are shown and described in Catalog 1343 of the Minneapolis-Honeywell Regulator Co., Brown Instruments Div., Philadelphia 44, Pa.

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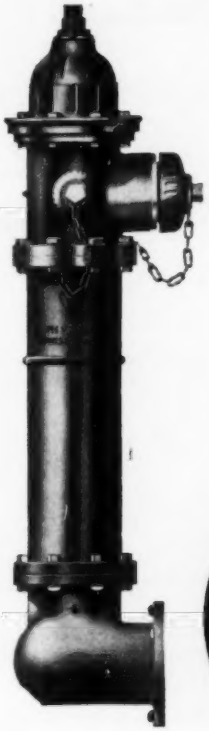

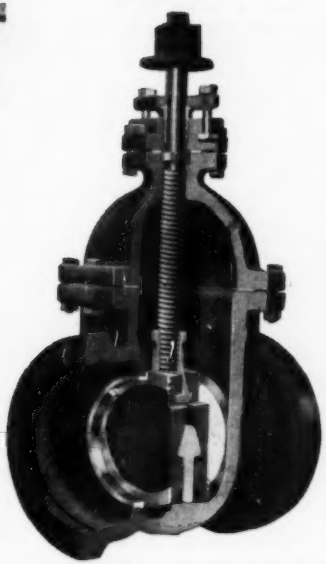

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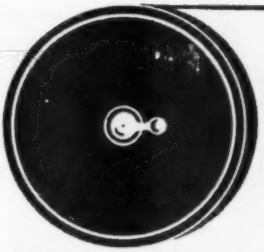

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Mueller Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
A. P. Smith Mfg. Co.
Worthington-Gamon Meter Co.

Meter Reading and Record Books:
Badger Meter Mfg. Co.
Buffalo Meter Co.

Meter Testers:
Badger Meter Mfg. Co.
Ford Meter Box Co.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.

Meters, Domestic:
Badger Meter Mfg. Co.
Buffalo Meter Co.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
A. P. Smith Mfg. Co.
Well Machinery & Supply Co.
Worthington-Gamon Meter Co.

Meters, Filtration Plant, Pumping Station, Transmission Line:
Builders-Providence, Inc.
Infilco, Inc.
Simplex Valve & Meter Co.
R. W. Sparling

Meters, Industrial, Commercial:
Badger Meter Mfg. Co.
Buffalo Meter Co.
Builders-Providence, Inc.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
Simplex Valve & Meter Co.
A. P. Smith Mfg. Co.
R. W. Sparling
Well Machinery & Supply Co.
Worthington-Gamon Meter Co.

Mixing Equipment:
Belco Industrial Equipment Div., Inc.
Chain Belt Co.
Infilco, Inc.
Walker Process Equipment, Inc.

Ozonation Equipment:
Welsbach Corp., Ozone Processes Div.

Pipe, Asbestos-Cement:
Johns-Manville Corp.
Keasbey & Mattison Co.

Pipe, Brass:
American Brass Co.

Pipe, Cast Iron (and Fittings):
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
Central Foundry Co.
James B. Clow & Sons
United States Pipe & Foundry Co.
Warren Foundry & Pipe Corp.
R. D. Wood Co.

Pipe, Cement Lined:
Cast Iron Pipe Research Assn.
Central Foundry Co.
James B. Clow & Sons
Preload Companies, The
United States Pipe & Foundry Co.
Warren Foundry & Pipe Corp.
R. D. Wood Co.

Pipe Coatings and Linings:
The Barrett Div.
Cast Iron Pipe Research Assn.
Centriline Corp.
Koppers Co., Inc.
Preload Companies, The
Reilly Tar & Chemical Co.
Standard Pipeprotection, Inc.
Warren Foundry & Pipe Corp.

Pipe, Concrete:
American Pipe & Construction Co.
Lock Joint Pipe Co.

Pipe, Copper:
American Brass Co.

Pipe Cutting Machines:
Ellis & Ford Mfg. Co.
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.

Pipe Jointing Materials:
(See Jointing Materials)

Pipe, Steel:
Armco Drainage & Metal Products, Inc.
Bethlehem Steel Co.

Plugs, Removable:
James B. Clow & Sons
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.
Warren Foundry & Pipe Corp.

Potentiometers:
Hellige, Inc.

Pressure Regulators:
Ross Valve Mfg. Co.

Pumps, Boiler Feed:
DeLaval Steam Turbine Co.
Fairbanks, Morse & Co.
Peerless Pump Div., Food Machinery Corp.

Pumps, Centrifugal:
American Well Works
DeLaval Steam Turbine Co.
Economy Pumps, Inc.
Fairbanks, Morse & Co.
Peerless Pump Div., Food Machinery Corp.

Pumps, Chemical Feed:
Everson Mfg. Corp.
Infilco, Inc.
Proportioneers, Inc.
Wallace & Tiernan Co., Inc.

Pumps, Deep Well:
American Well Works
Fairbanks, Morse & Co.
Layne & Bowler, Inc.
Peerless Pump Div., Food Machinery Corp.
Worthington Pump & Mach. Corp.

Pumps, Diaphragm:
Dorr Co.
Proportioneers, Inc.

Pumps, Hydrant:
Jos. G. Pollard Co., Inc.

Pumps, Hydraulic Booster:
Fairbanks, Morse & Co.
Ross Valve Mfg. Co.

Pumps, Sewage:
DeLaval Steam Turbine Co.
Economy Pumps, Inc.
Fairbanks, Morse & Co.
Peerless Pump Div., Food Machinery Corp.

Pumps, Sump:
DeLaval Steam Turbine Co.
Economy Pumps, Inc.
Fairbanks, Morse & Co.
Peerless Pump Div., Food Machinery Corp.

HAYS

WATER SERVICE PRODUCTS

for efficient maintenance

CORPORATION STOP

DUO-STOP CORPORATION STOP and SADDLE COMBINED

ROUNDWAY CURB STOP and DRAIN

INVERTED PLUG CURB STOP

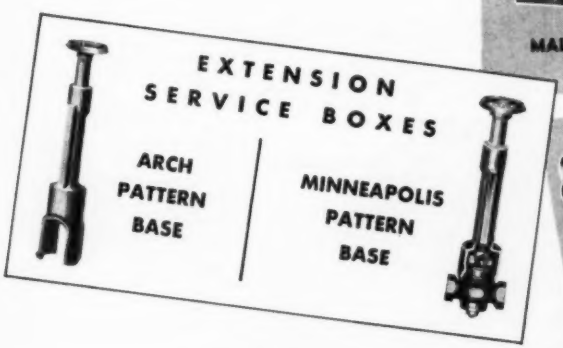
MALE ADAPTOR

UNION

MALE ELBOW

OVER 80 years of manufacturing experience . . . designed for easy installation . . . long years of trouble-free service . . . interchangeable with those of other manufacturers . . . corporation stops can be installed with any standard tapping machine.

All Hays fittings made of single, uniform, high quality water service bronze, 85-5-5-5 mix . . . hydrostatically tested at 200 pounds or more . . . plugs individually ground in for perfect fit . . . specially lubricated for permanent easy turning.



HAYS MANUFACTURING COMPANY
12 TH & LIBERTY STREETS, ERIE, PENNA., U. S. A.

Pumps, Turbine:
DeLaval Steam Turbine Co.
Fairbanks, Morse & Co.
Layne & Bowler, Inc.
Peerless Pump Div., Food Machinery Corp.
Worthington Pump & Mach. Corp.

Recorders, Gas Density CO_2, NH_3, SO_2, etc.:
Permutit Co.
Wallace & Tiernan Co., Inc.

Recording Instruments:
Builders-Providence, Inc.
Infilco, Inc.
R. W. Sparling
Wallace & Tiernan Co., Inc.

Reservoirs, Steel:
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Sand Expansion Gages:
(See Gages)

Sleeves:
(See Clamps)

Sleeves and Valves, Tapping:
James B. Clow & Sons
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Sludge Blanket Equipment:
Permutit Co.

Soda Ash:
Solvay Sales Div.

Sodium Hexametaphosphate:
Calgon, Inc.

Softeners:
Belco Industrial Equipment Div., Inc.
Dorr Co.
Hungerford & Terry, Inc.
Infilco, Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.

Softening Chemicals and Compounds:
Calgon, Inc.
Infilco, Inc.
Permutit Co.

Standpipes, Steel:
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Steel Plate Construction:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Storage Tanks:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Strainers, Suction:
M. Greenberg's Sons
R. D. Wood Co.

Sulfur Dioxide, Liquid:
Virginia Smelting Co.

Surface Wash Equipment:
Permutit Co.
Stuart Corp.

Swimming Pool Sterilization:
Belco Industrial Equipment Div., Inc.
Everson Mfg. Corp.
Omega Machine Co. (Div., Builders Iron Fdry.)
Proportioneers, Inc.
Wallace & Tiernan Co., Inc.
Welsbach Corp., Ozone Processes Div.

Tanks, Steel:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Tapping Machines:
Hays Mfg. Co.
Mueller Co.
A. P. Smith Mfg. Co.

Taste and Odor Removal:
Industrial Chemical Sales Div.
Infilco, Inc.
Proportioneers, Inc.
Walker Process Equipment, Inc.
Wallace & Tiernan Co., Inc.
Welsbach Corp., Ozone Processes Div.

Telemeters, Level, Pump Control, Rate of Flow, Gate Position, etc.:
Builders-Providence, Inc.

Turbidimetric Apparatus (For Turbidity and Sulfate Determinations):
Hellige, Inc.
Wallace & Tiernan Co., Inc.

Turbines, Steam:
DeLaval Steam Turbine Co.

Turbines, Water:
DeLaval Steam Turbine Co.

Valve Boxes:
Central Foundry Co.
James B. Clow & Sons
Ford Meter Box Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valve Inserting Machines:
A. P. Smith Mfg. Co.

Valves, Altitude:
Ross Valve Mfg. Co., Inc.

Valves, Butterfly, Check, Flap, Foot, Hose, Mud and Plug:
James B. Clow & Sons
M. Greenberg's Sons
Rensselaer Valve Co.
R. D. Wood Co.

Valves, Detector Check:
Hersey Mfg. Co.

Valves, Electrically Operated:
James B. Clow & Sons
Kennedy Valve Mfg. Co.
Philadelphia Gear Works, Inc.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Valves, Float:
Ross Valve Mfg. Co., Inc.

Valves, Gate:
Dresser Mfg. Div.
James Jones Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Hydraulically Operated:
James B. Clow & Sons
Kennedy Valve Mfg. Co.
Philadelphia Gear Works, Inc.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Large Diameter:
James B. Clow & Sons
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Regulating:
Ross Valve Mfg. Co.

Valves, Swing Check:
James B. Clow & Sons
M. Greenberg's Sons
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Waterproofing
Inertol Co., Inc.

Water Softening Plants:
(See Softeners)

Water Supply Contractors:
Layne & Bowler, Inc.

Water Testing Apparatus:
Hellige, Inc.
LaMotte Chemical Products Co.
Photovolt Corp.
Wallace & Tiernan Co., Inc.

Water Treatment Plants:
American Well Works
Chain Belt Co.
Chicago Bridge & Iron Co.
Dorr Co.
Everson Mfg. Corp.
Hungerford & Terry, Inc.
Infilco, Inc.
Pittsburgh-Des Moines Steel Co.
Roberts Filter Mfg. Co.
Stuart Corp.
Walker Process Equipment, Inc.
Wallace & Tiernan Co., Inc.
Welsbach Corp., Ozone Processes Div.

Well Acidizing:
Dowell Incorporated

Well Drilling Contractors:
Layne & Bowler, Inc.

Wrenches, Ratchet:
Dresser Mfg. Div.

Zeolite:
Hungerford & Terry, Inc.
Infilco, Inc.
Permutit Co.
Roberts Filter Mfg. Co.

A complete Buyers' Guide to all water works products and services offered by A.W.W.A. Associate Members appears in the 1948 Membership Directory.

INTRODUCING THE W&T MERCHEN SCALE FEEDER

FOR WATER AND SEWAGE TREATMENT CHEMICALS

Wallace & Tiernan is proud to offer this machine, proven by nine years' experience in the flour, grain, and chemical industries, to those water works operators who desire maximum accuracy, simplicity, and dependability in dry chemical feeding equipment.

WHAT THE FEEDER DOES—Feeds continuously and accurately at rate selected by operator—Scale beam calibrated in pounds per unit of time—Once rate is chosen, feeder automatically adjusts itself to that rate, thus eliminates calibration regardless of material fed — Quantity of chemical fed recorded on tally unit.

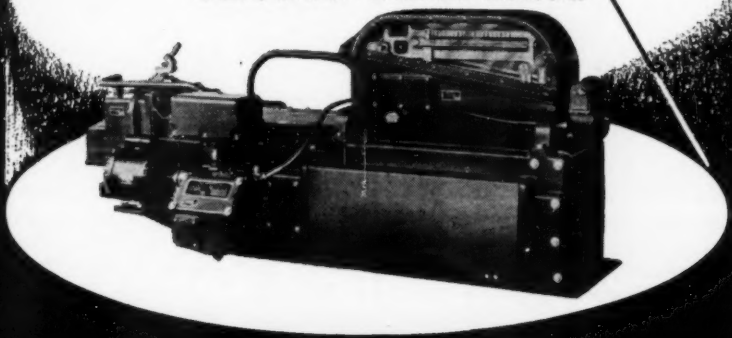
HOW IT WORKS—Feeds BY WEIGHT using constant speed belt drive with variable speed screw feed section, thus eliminates inherent inaccuracy of variable belt speed method.

ADVANTAGES—Totally enclosed motors, oil seals on all bearings, oil baths for drive gears, dust-tight beam enclosure —Provides minimum maintenance and insures high accuracy of feeder for life of machine—Adaptable to program or proportional control—Alarm systems can be added—Wide range up to 2 cu. ft./min.—Extreme accuracy provides maximum economy in feeding of chemicals.

Communicate with your nearest W&T representative and he will gladly furnish you with complete information on the W&T Merchen Scale Feeder.

WALLACE & TIERNAN COMPANY, INC. M-12

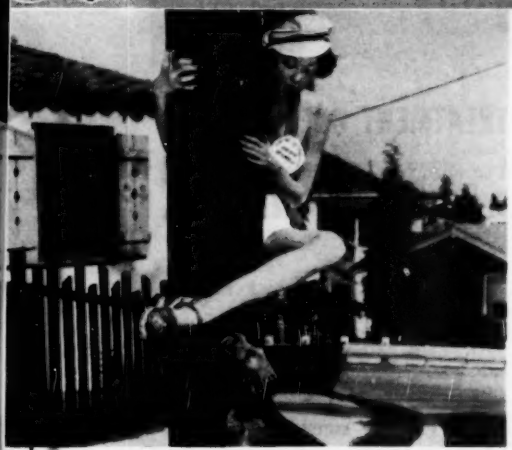
CHLORINE AND CHEMICAL CONTROL EQUIPMENT
NEWARK 1, NEW JERSEY • REPRESENTED IN PRINCIPAL CITIES



The "GREAT GILDERSLEEVE" *

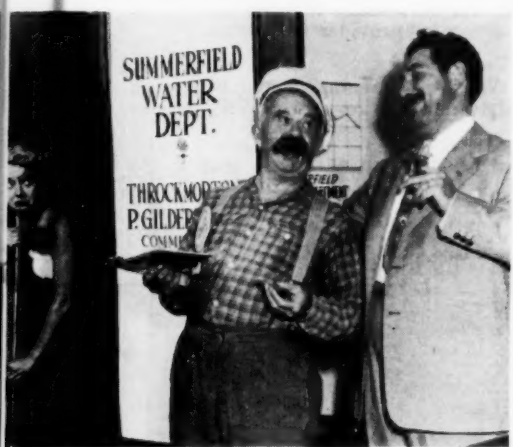
*STARRING HAROLD PEARY—ON THE AIR FOR KRAFT FOODS COMPANY OVER N.B.C.

. . . FINDS NEW TWISTS MULTIPLY OLD TROUBLES

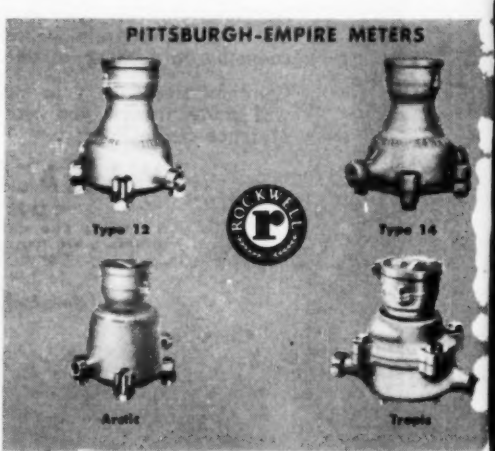


If there isn't a meter at the top of this pole, one of Gildy's new Meter Readerettes is going to have a little trouble. Gildy's scheme seems to be going to the dogs, doggonit.

Gildersleeve's new twist takes a nasty turn as the complaints pour in. "My water bill looks like I'd been backfilling Hoover Dam." Chester Conklin, says, "Here's another beef." Gildy moans.



"After all, Chester, meter reading is a man's job," says Gildy. Go out and read those Pittsburgh meters right so we can reap the profit as never before. Good old faithful, dependable Chester, you're for me."



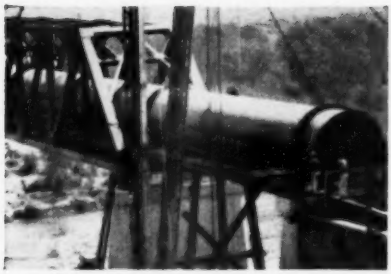
Seriously speaking, there's nothing that equals these meters for faithful performance, extreme accuracy and long life.

PITTSBURGH EQUITABLE METER DIVISION

ROCKWELL MANUFACTURING COMPANY

Pittsburgh 8, Pa.

Atlanta Boston Chicago Houston Kansas City Los Angeles New York Pittsburgh San Francisco Seattle Tulsa



Above Ground

Corrosion insurance

Under Ground

Copy of this booklet, describing Reilly coatings for metal, brick, cement and wood surfaces, will be sent od request.

Above ground or under ground—whether exposed to the searing desert sun or buried in the cold, damp soil beneath city streets, Reilly Enamel provides water lines with dependable, lasting protection against corrosion.

The tough, durable Reilly coating protects both the outer and inner surfaces of steel pipe against corrosive agencies of all kinds. The inside of the pipe is also protected against incrustation and tuberculation, thus helping insure full capacity flow for the life of the pipe.

REILLY TAR & CHEMICAL CORPORATION

Merchants Bank Bldg., Indianapolis 4, Indiana

500 Fifth Ave., New York 18, N. Y. — 2513 S. Damen Ave., Chicago 8, Illinois

Reilly Protective Coatings

LEADITE

Trade Mark Registered U.S. Pat. Office

Jointed for . . . Permanence with LEADITE

Generally speaking, most Water Mains are buried beneath the Earth's surface, to be forgotten,—they are to a large extent, laid for permanency. Not only must the pipe itself be dependable and long lived,—but the joints also must be tight, flexible, and long lived,—else leaky joints are apt to cause the great expense of digging up well-paved streets, beautiful parks and estates, etc.

Thus the "jointing material" used for bell and spigot Water Mains MUST BE GOOD,—MUST BE DEPENDABLE,—and that is just why so many Engineers, Water Works Men and Contractors aim to PLAY ABSOLUTELY SAFE, by specifying and using LEADITE.

Time has proven that LEADITE not only makes a tight durable joint,—but that it improves with age.

The pioneer self-caulking material for c. i. pipe.
Tested and used for over 40 years.
Saves at least 75%

THE LEADITE COMPANY
Girard Trust Co. Bldg. Philadelphia, Pa.

No Caulking